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**Separate Maps** published in the *Geographical Review* and the *Bulletin of the American Geographical Society*, the majority in color. 25 cents each. **A list will be sent upon request.**

THE
GEOGRAPHICAL REVIEW

VOL. XIX JANUARY, 1929 NO. 1

# THE 1927–1928 PERUVIAN EXPEDITION OF THE AMERICAN GEOGRAPHICAL SOCIETY

O. M. Miller

*American Geographical Society's School of Surveying*

[With separate map, Pl. I, facing p. 32]

THE 1927–1928 Peruvian Expedition of the American Geographical Society was undertaken in conjunction with the program of geographical studies on which the Society's Department of Hispanic American Research is now engaged.[1] A cartographic base is a necessary preliminary; and for the past eight years the Society has been assembling, from all possible sources, surveys and other materials for the compilation of this map. There still are, however, areas in which no surveys have been made or in which such surveys as have been made are not well located with respect to one another. One of the most important of these areas lies west and north of Cerro de Pasco. It extends from the main crest of the Cordillera of the Andes to the Pachitea River. It includes that section of the main cordillera which constitutes the watershed between the Pacific Ocean and three great tributaries of the Amazon which have their headwaters in the region—within a space of 20 miles—the Marañon, the Huallaga, and the Mantaro. A large section of the region is well populated; its western border is known to be highly mineralized; its eastern border recommends itself for future colonization because of its rich soil and equable climate. Most of the region was found to be unknown cartographically except for rough sketch maps and a few river traverses which had not been accurately located by triangulation or by astronomical observations.

The area was so large and so important that it was impossible satisfactorily to compile the Cerro de Pasco sheet until better maps

[1] R. R. Platt: The Millionth Map of Hispanic America, *Geogr. Rev.*, Vol. 17, 1927, pp. 301–308.

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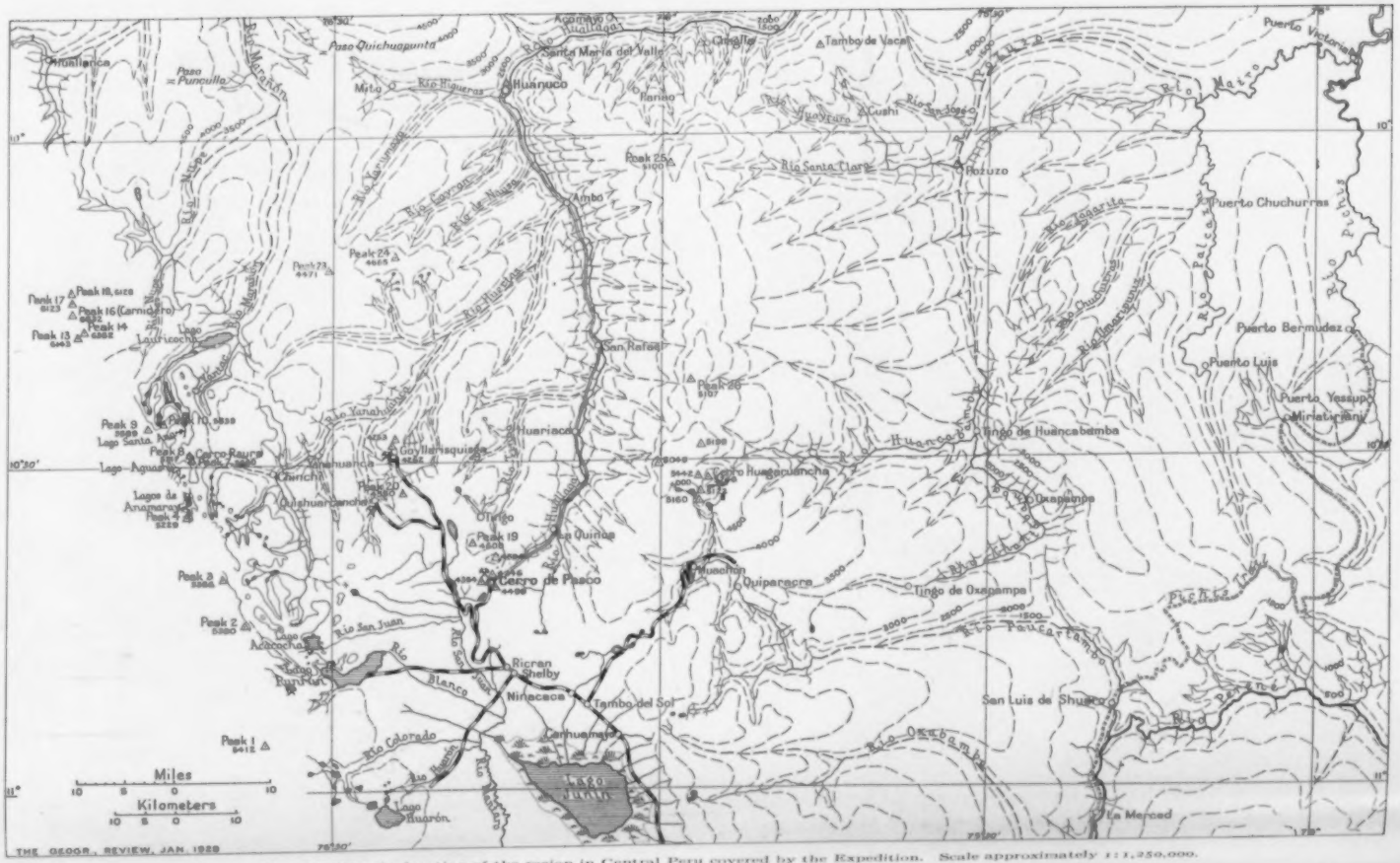
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Río Yacuruna
Río Huayurco
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FIG. 2

FIG. 3

FIG. 2—Cerro de Pasco, looking north. The high hill to the left of the center is Station No. 1, from which place the diagrammatic sketches of the peaks to the west and east of Cerro de Pasco were made (FIG. 44).

FIG. 3—Street scene in Cerro de Pasco.



THE GEOGR. REVIEW, JAN. 1918

FIG. 1—Map showing the location of the region in Central Peru covered by the Expedition. Scale approximately 1:1,250,000.

became available. The Society, therefore, decided to send a party, consisting of the writer as leader and Mr. Kaspar M. Hodgson as assistant, into the field to conduct surveys and make a study of the geographical features. The Peruvian government showed great interest in the expedition and placed every facility at its disposal. The party was lent government mules and provided with a military escort under the capable command of Captain Benjamin Chiurliza.

FIG. 4—Looking southeast from Station 1, Cerro de Pasco. This is near the divide between the more level country to the south and the more deeply dissected country to the north. Compare Figure 5.

## WORK AT CERRO DE PASCO

The first objective of the expedition was the establishment of a large number of geographical positions by astronomical or trigonometrical methods which could be used as a framework on which to fit local surveys. Headquarters were taken up at Cerro de Pasco, that old town whose fame in South American mining annals is rivaled only by Potosí. We arrived on July 11, 1927, and were kindly accommodated at the hotel of the Cerro de Pasco Company, where we stayed three weeks. The Company's officials were most obliging and helped us in many ways. We used their triangulation stations and thus were spared the necessity of measuring a base. The triangulation was extended to points sufficiently far apart to enable good intersections to be made of the principal points visible to west and east.

The Cerro de Pasco region has been given great importance in classic descriptions of the Peruvian Andes as a mountain knot tying together three distinct cordilleras. Actually the "Nudo" is merely an erosion remnant of the Andean plateau. It constitutes the divide between the Huallaga River system to the north and the Mantaro to the south. The surface of the plateau, which here has a maximum width of 40 miles, is studded with shallow lakes and marshlands. There is, however, a marked difference in relief between the northern and southern slopes of the watershed; the streams of the former have

cut deep gorges into the surface, whereas those of the latter meander in shallow valleys. As the Peruvians say, the relief is respectively "quebrado" and "llano."[2] On the west is the main cordillera of the Andes, which here constitutes the Atlantic-Pacific divide. It consists of a series of ridges in echelon to which the general name of Cordillera de Huayhuash has been given. From Cerro de Pasco can be seen two groups of high mountains in this cordillera, the first to the west

FIG. 5—Looking northeast from Station 1, Cerro de Pasco. Compare Figure 4.

culminating in the Raura peak, which we found to be 34 miles distant and 18,755 feet high. The second group is over 50 miles away and more to the northwest. It is also much higher, including five or six peaks more than 20,000 feet above sea level. The highest is Carnicero, 21,760 feet, among Peruvian peaks second in elevation only to Huascaran (22,182 feet) in the Cordillera Blanca, which succeeds the Cordillera de Huayhuash northward.

On the east the plateau is flanked by bare undulating foothills rising to the eastern range, whose peaks do not exceed 18,000 feet except in the case of the snow-clad Huaguarancha, 18,797 feet. We saw a number of whitened peaks farther north, but whether they have snow on them all year round is not known. At any rate the mountains get lower as the range proceeds north, and there is no definite continuation between this range and that which forms the divide between the Marañon River and the Huallaga. The true continuation of this eastern range appears to be that which lies to the east of the Huallaga River where the latter turns from flowing east to north. Here it forms the divide between the Huallaga and the Ucayali River systems. Later on in the season we crossed the range at this point and found the highest peaks to be not over 13,000 feet and wooded

[2] Enrique I. Dueñas: Reconocimiento geológico-minero de la cuenca carbonera setentrional Lima-Junín (Hoyas de Oyon, Checras y Pasco), *Bol. Cuerpo de Ingenieros de Minas del Perú No. 97*, Lima, 1919.

FIG. 6

FIG. 7

FIG. 8

FIG. 6—Looking east across the flat Nudo de Cerro de Pasco from an isolated limestone ridge to the east of Lake Tucapa. The eastern range in the background.

FIG. 7—Looking across the flat Andean plateau here between 4300 and 4400 meters high.

FIG. 8—Raco, a village on the flat plateau.

FIG. 9

FIG. 10

FIG. 11

FIG. 9—Carnicero seen from Station No. 1, Cerro de Pasco. Compare Figure 44.
FIG. 10—The flat upper pampa to the north of the Colpa Grande (4600 meters) looking north.
FIG. 11—Looking northwards towards Lake Acacocha which lies under the mountains in the background.

FIG. 12—Looking northwest across Lake Acacocha. Note the glacial deposit in the foreground, preventing drainage from lake southward. The hut and corral in the foreground to the right furnish a scale.

FIG. 13—Looking west from an isolated limestone ridge east of Lake Tucapa. The lake lies at the foot of a grassy quebrada 250 meters below the pampa seen in the photograph and between it and the limestone ridge. The snow-capped peaks on the sky line are part of the main Atlantic-Pacific divide. Compare Figure 6, which is taken from the same spot.

FIG. 14

FIG. 15

FIG. 14—Lake Acacocha and vicinity from a hill just east of Lake Punrún.
FIG. 15—Looking west from the upper valley of the River Nupe to the region of high peaks. Carnicero on the right.

almost to their summits. From the most reliable information we could get we gathered that the mountains do not continue far in this direction but eventually descend to the Pampas de Sacramento.

## Topographical Reconnaissance of the Mantaro-Huallaga Watershed

When the work at Cerro de Pasco was finished and the positions determined had been plotted on the plane-table sheets, we crossed the plain to its western edge where at Jumashi we were hospitably received by officials of the Vanadium Corporation. Here the main divide rises abruptly from the level of a flat pampa, much higher than the main plateau and separated from it by one or more parallel limestone ridges. On the eastern face of the main divide there are no glaciers or snow, but there is plenty of evidence that this has not always been the case. Some of the higher peaks here, though not exceeding 18,000 feet, have permanent snow and ice on their southwestern faces. As seen from the northeast this presents the curious effect of a thin white rim above the silhouetted rock outline. The most westerly branch of the Mantaro River, the Jumashi, has its source close up under the main divide on one of the high grass-covered pampas, along which it flows until near Mina Ragra, the Vanadium Corporation's mine, it turns abruptly east, cuts through a limestone ridge parallel to the main cordillera, and drops into Lake Punrún. The lake is between seven and eight miles long and at an altitude of 14,100 feet. The Vanadium Corporation carries its ores by a light railway to the western end of the lake and thence by motor launch to the eastern end. Thus Punrún can claim to be the highest navigated lake in the world.

The system of high flat upper valleys between parallel limestone ridges is a characteristic feature of the Atlantic side of the main divide in this region. The eastern faces of the ridges are very precipitous, and lakes nestle at their base. Small streams flow through the limestone country in narrow and crooked gorges in which are numerous little hidden lakes. North of the Jumashi none of these gorges penetrates through to the upper valleys or the main divide until the Colpa Grande, a tributary of the Huallaga, is reached. In this latter valley and others farther north the streams start right at the base of the main divide; they flow in deep glacial troughs that are bordered by high lateral valleys. In one place, for example, north of the Colpa Grande, the streams in the upper valleys drop precipitously 2000 feet into a canyon-like valley which has penetrated through the limestone ridges but no farther.

From Jumashi, skirting the northern edge of Lake Punrún and keeping to the east of the limestone ridges but close to them, we

FIG. 14—[illegible]
FIG. 15—Looking west from the upper valley of the River Nupe to the region of high peaks [illegible]

proceeded north along the pampa, crossing the Mantaro-Huallaga divide. Our first camp was on the western shore of Lake Acacocha, 14,635 feet in altitude. We were here several days making side trips into the mountains and becoming accustomed to the altitude. This picturesque lake is the most northerly to drain into the Mantaro River. On its eastern side is comparatively flat pampa extending for many miles to the eastern range of mountains, which can be seen far in the distance. On its other sides it is surrounded by precipitous limestone peaks, the highest of which rises 2220 feet above the surface of the lake. Several small streams flow into Lake Acacocha from other little hidden lakes to the west. Up one of the stream valleys is a trail which crosses over the limestone ridges to the upper pampa, the valley of the Jumashi River. At the pass it skirts one of the few glaciers actually to the east of the main Atlantic-Pacific divide.

As soon as the watershed is passed one notices the feature to which reference has already been made—that the streams flowing north into the Huallaga have cut their valleys far deeper into the surface of the general plateau. Lake Tucapa, still on the dividing line between the pampa and the limestone area, lies at the foot of a grassy quebrada 900 feet lower than the watershed on the pampa but within two miles of it. The stream on which we camped, characteristically fed from this lake at the foot of the limestone peaks, is a tributary of the Yanahuanca River, which flows into the Huallaga at Ambo. The Colpa Grande, already referred to, joins this stream five or six miles farther north. Here is an area of confused topography; but as soon as the glacial trough of the Colpa Grande is crossed one has again the main divide, the high upper pampa, the limestone ridges, and the main plateau clearly differentiated as before.

The particular stretch of upper pampa to the north of the Colpa Grande is ended abruptly by a massive red sandstone spur of the main cordillera. At its northeasterly corner streams collect from all directions to drop 2000 feet into the Chinchi by a series of cascades. The soil on the pampa is composed for a large part of rich red clay and shows evidence of very recent stream erosion in the shallow valleys, 30 to 40 feet deep, with bare sides in places nearly perpendicular.

The main trail from Yanahuanca to Oyon on the western side of the Atlantic-Pacific divide ascends from the canyon onto the upper pampa and thence over the divide by a very low pass. Our route, however, crossed this at right angles. Proceeding by a lateral pass between the main divide and the red sandstone spur, we came into the deep glacial valley of the Anamaray River. On the other side of the valley one is confronted by the big snow-clad range which culminates in the Raura peak. Our problem was to reach the source of the Marañon River at Lake Santa Ana, which lies directly the other

FIG. 16

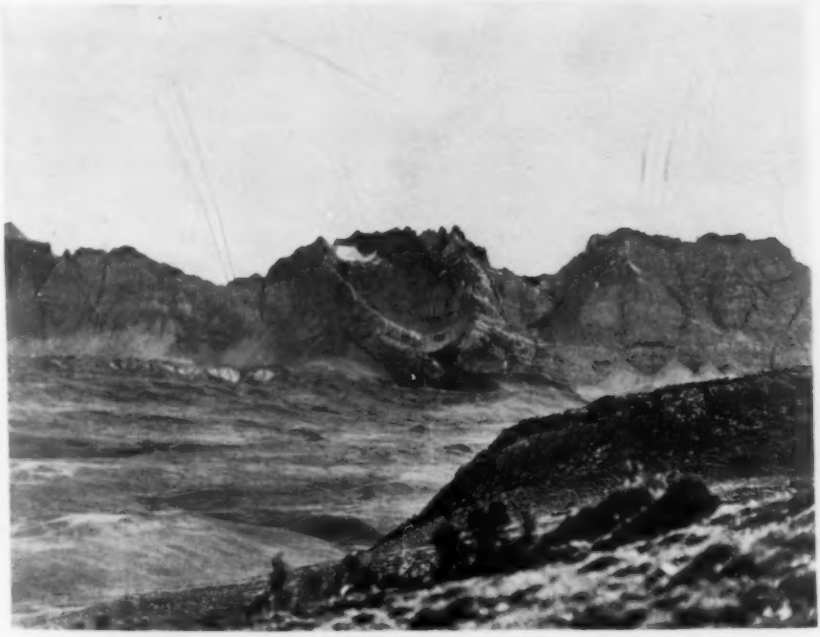


FIG. 17

FIG. 16—Looking west across northwest corner of Lake Punrún. Note the cirques of the main Atlantic-Pacific divide in the distance and the high upper pampas between the divide and the limestone ridge of the foreground. Through the latter the Jumashi River has cut a gorge (see left of picture).

FIG. 17—A closer view of the Atlantic-Pacific divide and upper Jumashi pampa. Compare Figure 16.

side of Raura. The best approach lay round the western side of the peak, or across the Atlantic-Pacific divide. The high lateral valleys on the Pacific side we found distinctly different from those just left. Glaciers and snow fields were much in evidence. About eight miles to the north, at the head of a small lateral valley, we were confronted by a group of very high peaks and glaciers; but a trail was found which ascended to the east. At the top of the rise we found ourselves looking down a few hundred feet into beautiful little Lake Potosí at the foot of a large glacier coming off Raura peak. Lake Potosí is completely surrounded by glaciers and loose shale hills and has no visible drainage outlet, though a fast-running stream from another little lake to the west, also glacier-fed, flows into it. No doubt the drainage from the lower lake is subterranean: but do its waters flow into the Huallaga or the Marañon or the Pacific?

FIG. 18—Lake Potosí from the west.

Two miles north across loose shale hills we dropped down into the glacial basin of Lake Santa Ana. This lake is held to be the true source of the Amazon, justly so in my opinion. Towering directly above are snow-capped peaks rising over 2600 feet above its surface, and an enormous glacier abruptly terminates on the lake's edge in a solid wall of ice judged to be at least 100 feet high. We camped by it for several days and were often wakened in the night by the deep boom of ice falling into the water.

A silver and lead mine has just been started at Santa Ana. No ore

had as yet been extracted. It is proposed eventually to transport it by llama pack train to Oyon west of the Cordillera, whence the Pacific coast is reached at Huacho.

The valley from Lake Santa Ana turns to the north, and one passes a succession of gloomy lakes. To the southeast is a comparatively flat glacier on the Raura massif. It is the one by which Miss Annie Peck climbed a peak of the mountain in 1906.[3]

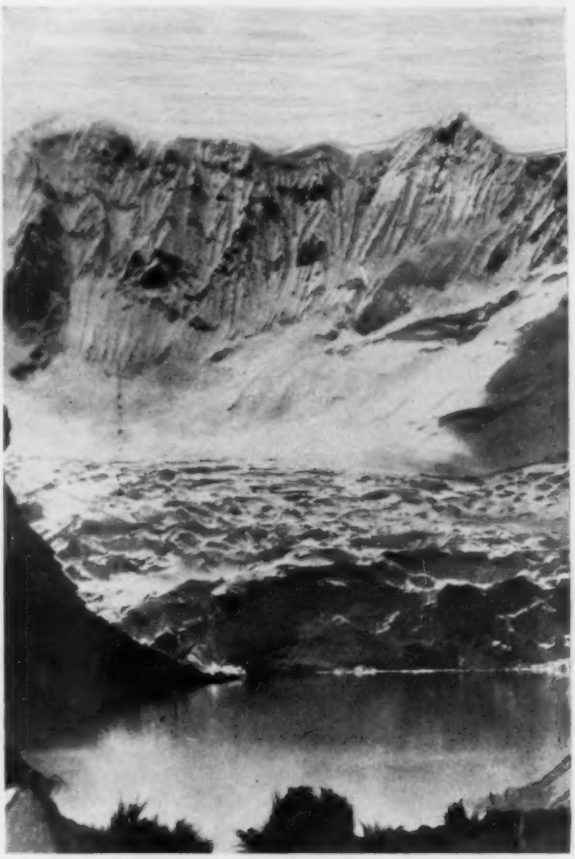


FIG. 19—Lake Santa Ana from the south.

The trail is poor and at the northern end of Lake Tinquicocha leaves the valley and proceeds in a northeasterly direction to Lake Lauricocha by way of the valley of the Yantac River. A former trail that followed the main stream has been deliberately destroyed by the owners of the ranch at Antacallanca to prevent the depredations of cattle thieves. We sent the baggage mules round by the ordinary trail and ourselves succeeded in going down the main quebrada. Previous maps we found to be entirely unreliable: the number and position of the lakes were not shown correctly, the long gorge between lakes Patarcocha and Lauricocha has never been indicated, nor a series of lakes to the west of Patarcocha. We made a side trip of several days up into the unexplored lake country and across a high divide to the valley of the Nupe River, which has its source close to the awe-inspiring Carnicero.

This ended our work in the high mountain region, and we returned

[3] A. S. Peck: A Search for the Apex of America, New York, 1911, Chapters 22 and 23.

FIG. 20

FIG. 21

FIG. 20—Wharf on Lake Punrún.
FIG. 21—An isolated peak south of Lake Potosí, photographed from the west.

to Lake Lauricocha, camping at the eastern end for several days. The lake itself is considerably longer than estimated by Sievers[4] and trends more west-east than southwest-northeast in direction. The eastern end of Lake Lauricocha, whence issues the Marañon to flow northward, is only a few hundred feet below the surface of the surrounding plateau, the mountainous region having been left halfway down the lake. The main trail between Yanahuanca and Huallanca crosses the Marañon just below Lake Lauricocha by a bridge, supposed to be of Inca construction, and the part of the trail between Lauricocha and Huallanca was the route proposed by the Intercontinental Railroad Commission in 1894.

## WEATHER ON THE PLATEAU

At Cerro de Pasco on the eastern side of the plateau and at more or less the same height as the camps we occupied in the mountains, the average daily mean temperature over a period of 14 days

[4] Wilhelm Sievers: Reise in Peru und Ecuador ausgefuhrt 1909, *Wiss. Veroffentl. Gesell. für Erdkunde zu Leipzig*, Vol. 8, Munich and Leipzig, 1914, p. 29. He is followed by Pierre Denis in a map of the sources of the Marañon, Amérique du Sud (Géographie Universelle, Vol. 15), Part II, 1928, p. 291.

in July (14–27) was about 43° Fahrenheit with a maximum of 63° and a minimum of 20°.[5] We experienced the greatest extremes in temperature while on the western edge of the main plateau, undoubtedly because of the fine weather and the comparatively low humidity. In the mountains during August and September, when we had a great deal of bad weather, though the average daily temperature remained about the same the maximum and minimum had a much smaller amplitude.[6] The greatest 24-hour range, from 64° to 14° (Aug. 18), was at Lake Tucapa, where we also experienced the lowest relative humidity with an average daily mean of 53 per cent over four days (Aug. 17–20), the highest observation being 84 and the lowest 19. The observations were for the most part taken in camp, that is to say in sheltered places, and the average daily mean temperature was just over

FIG. 22

FIG. 23

FIG. 22—On the Pacific side of the Anamaray pass looking east.

FIG. 23—Above Lake Potosí (Fig. 18) looking east.

[5] Observations in 1908 at Cerro de Pasco gave the monthly mean temperature in July as 38.6° F., the absolute extremes as 60° and 21°; for the year the mean as 42.6° and extremes as 69° and 21° (Fritz von Kerner: Temperatur- und Regenmessungen aus Peru, *Meteorol. Zeitschr.*, Vol. 34, 1917, pp. 29–34).

[6] Compare records for the station of Morococha, in latitude 11° 45′ S. and immediately east of the crest line of the Maritime Cordillera (Isaiah Bowman: The Andes of Southern Peru, New York, 1916, pp. 171–173).

FIG. 24

FIG. 25

FIG. 24—Glacial erosion in the Anamaray Valley looking across the valley to the south.
FIG. 25—The Anamaray Valley looking northeast down the glacial trough.

40° F. as at Cerro de Pasco. Nothing lower than 12° F. (Lake Tucapa, Aug. 19) and nothing higher than 70° (at Camp 5, Sept. 3) was experienced in the whole of this mountain region.

The first two or three weeks after leaving Jumashi we had almost perfect weather. True, there were occasional snow flurries; and during this period a heavy mist settled completely over the landscape

FIG. 26—The unmapped lakes west of Lake Patarcocha.

before sunrise, often not clearing off until nine o'clock in the morning. The snowstorms and thunderstorms came on in the middle of the afternoon, and after nightfall it would clear again.

For a week on the upper pampa above the Chinchi canyon we saw the sun rarely for more than a few minutes; for the rest it was a succession of storms—snow, sleet, hail, rain, and thunder. But so powerful was the sunshine that not more than half an hour was required to remove all traces of a storm.

When we arrived at Lake Santa Ana, though it had been raining hard earlier in the day, the sun was shining brilliantly, and it was pleasant to stretch out full length on the warm grass. Half an hour later a black storm came rushing up the valley, and in a very short time the ground was covered with several inches of snow. There were many similar experiences of these characteristically sudden changes of weather. One is tempted to quote Wiener's description of the weather at Cerro de Pasco: "son ciel, dans une seule journée, dans

une seule heure souvent, paraît tantôt du bleu le plus transparent, tantôt noir; il envoie tour à tour des rayons brûlants, de la grêle, de la neige, de la pluie torrentielle, des éclairs enveloppant la ville entière, qui reparaît instantanément après, par l'effet d'un coup de vent, dans une splendeur incomparablement sereine."[7]

## The People of the Region

There were a great many more people living in this region than we had expected to find, amiable and friendly people, too. We had been

Fig. 27—Indian huts near the unmapped lakes shown in Figure 26.

warned to expect hostility before going into this country, and many were the uncorroborated tales of the killing of large bodies of Peruvian soldiers by the outlaw inhabitants. They originated I think from the fact that there had been a group of bandits in this region some years before who, besides preying on the local inhabitants, stealing their sheep, and plundering generally, had killed a Peruvian officer and several soldiers.

In the lower valleys the larger landowners maintain stock farms, and in the more remote regions the Indians themselves raise sheep and pigs; but habitations of one sort or another seemed to be everywhere. Though we had our own food supplies with us it was always possible to get fresh mutton. There is a law in Peru that a wayfarer if hungry may kill a sheep provided he pays the owner the sum of 1 sole, 50 centavos (approximately 56 cents). We took advantage of it on several occasions.

From Lauricocha we crossed the main plateau and came to the coal mines belonging to the Cerro de Pasco Company, where by means of the independent triangulation made there we were able to check up on the triangulation observations that had originally been made at Cerro de Pasco. This finished our work in the high mountain region.

[7] Charles Wiener: Pérou et Bolivie, Paris, 1880, p. 226.

## High Valleys of the Eastern Border

If we were surprised by the number of people inhabiting the high mountain area, we were still more surprised by the density of the population in the Yanahuanca and Huallaga quebradas above Huánuco. It is surprising that among the various routes that have been suggested for a concrete road or railway between Lima and the head of Amazonian navigation a route via Oyon and the Yanahuanca quebrada to Huánuco and beyond has not been proposed, for the population of the Yanahuanca quebrada is certainly much more dense than any portion of the Nudo de Cerro de Pasco over which most of the proposed routes would pass.

Fig. 28—A street scene in Yanahuanca.

The Yanahuanca district raises live stock in large numbers and crops, principally of the cold zone, potatoes in particular,[8] for which a ready market is found in Cerro de Pasco and the coal-mining centers of Goyllarisquisga and Quishuarcancha. The population lives not in separate groups of houses, as in the mountains we had just left, but in large villages that might almost be called towns.

The center of the district is Yanahuanca, a picturesque and comparatively clean place. It is built on a level with the river of that name, whereas most of the other towns and villages are perched on the sides of the quebradas which in this neighborhood are several thousand feet deep. As yet there is no motor road approaching Yanahuanca, but the trails are broad and good. The town has good stores and telegraphic communication with Lima. There is a Sunday market; and a fair, principally of live stock, is held on July 22 each year. The people of the district also resort to Cerro de Pasco for their shopping, taking the train there from Goyllarisquisga.

Coming down into the high border valleys from three months in the Puna it was exhilarating to see occasional trees, potatoes, and

[8] Dueñas, *op. cit.*, p. 129.

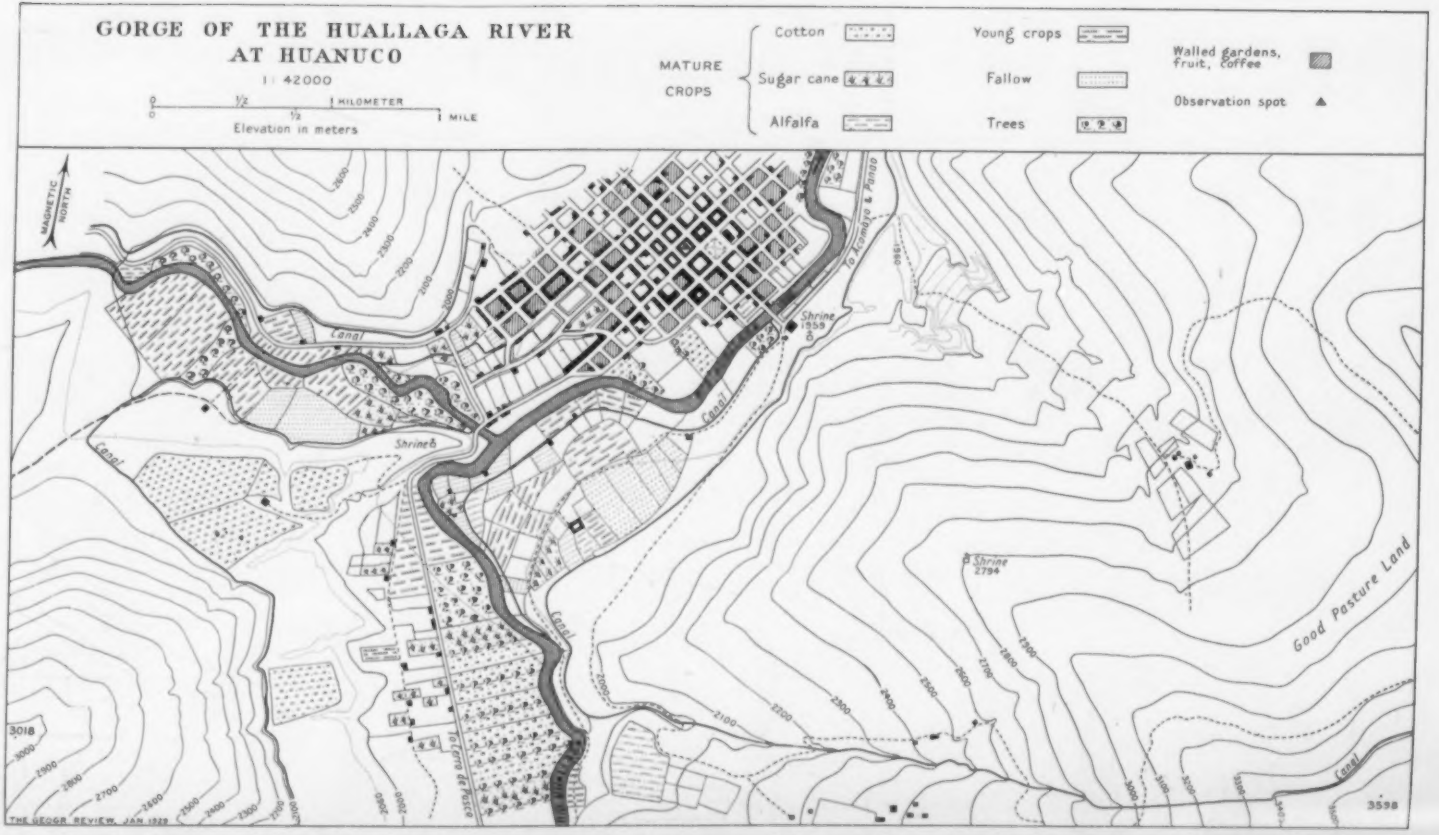



FIG. 29—Map showing topographical and cultural features of the gorge of the Huallaga at Huánuco. The map is accurately located by astronomical observations taken in the courtyard of the Hotel Inca: Latitude 9° 55′ 27″ South; Longitude 76° 14′ 12″ West. The datum level is taken at the bridge over the Huallaga, 1030 meters.

vividly green alfalfa. As Wiener says: "Il est extraordinaire comme des arbres meublent un paysage." There were also many beautiful flowers such as grow in gardens with us—roses, geraniums, arum lilies, gladioli. Nevertheless the country in these high secondary valleys is semiarid, as is evidenced by the predominating growth of cactus.

## Huánuco and the Huallaga

From Goyllarisquisga we returned to Cerro de Pasco for a reconnaissance trip into the montaña, which we entered by way of Huánuco. Huánuco is the capital of the department of that name and is a well laid out city, historically interesting as it was founded only four years after Lima.[9] The estimate of 1896 credited Huánuco with only 6000 population, less than half the population of Cerro de Pasco; but the writer judged the cities to be now about the same size. Huánuco is situated on the Huallaga at an elevation of 6400 feet above sea level and about 40 miles above the gorge of Piedra Grande, where the river turns north. The valley of the Huallaga at Huánuco is very deep, the immediate mountains rising 5000 feet above the valley floor to what is really the height of the main Andean plateau in the region. There are, however, individual mountains in the vicinity higher than this general level.

Irrigation in the Huánuco district is entirely artificial, irrigation canals being led off the main river and the side branches at suitable points. Much ingenuity has been expended over their construction. The deep valleys of the eastern Andes are semiarid. Without irrigation systems of this sort the quebrada of Huánuco would be almost a desert. Though no rainfall statistics are available it is very evident that the annual precipitation is extremely small. The lower sides of the quebrada have no vegetation at all growing on them except occasional cactus. The upper slopes have grass nearly all the year round.

The main valley floor is comparatively flat, the river meandering in broad sweeps from side to side. The current is rapid, there being few if any quiet reaches of deep water. Between the steep mountain sides and the valley floor are frequent remains of an upper alluvial terrace in which canyon-like watercourses, now generally dried up, are cut. The valley floors of the side quebradas, if such a name can be applied to such very steep slopes, are comparatively smooth except where cut by very recent stream erosion.

This whole region is purely agricultural. The bulk of the cultivation seems to be in the less steep side quebradas. Here alfalfa is a favorite crop. In the main valley citrus fruits, pineapples, and bananas are grown, mostly in and around the town of Huánuco or

[9] Compare the description in E. W. Middendorf: Peru, 3 vols., Berlin, 1893–95, Vol. 3, pp. 129–133.

Fig. 29—Map showing topographical and cultural features of the gorge of the Huallaga at Huánuco. The map is accurate. The datum level is taken at the bridge over the Huallaga, 1930 meters, the courtyard of the Hotel Inca. Latitude 9° 55' 27" South; Longitude 76° 14' 12" West.

behind the high walls of the *haciendas* of the larger landowners in this neighborhood. Much sugar cane is to be seen, and cotton is also now being grown extensively but only on the large estates. Huánuco coffee is famous, though much exported under the name is grown much farther down the river, as that on the *haciendas* of Sr. Antonio

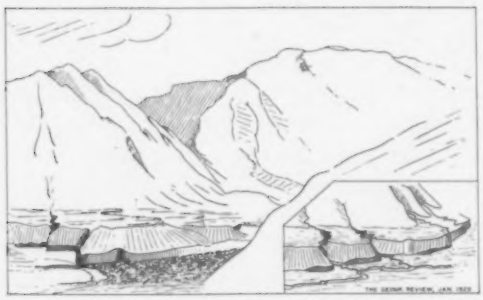


FIG. 30

FIG. 31

FIG. 32

FIGS. 30–32—Diagrammatic sketches at Huánuco and vicinity. Figure 30 is looking up the Huallaga to the west of Huánuco; the inset shows general appearance of the alluvial terraces bordering the main quebradas. Figure 31 is looking up one of the steep side quebradas. Figure 32 is looking up the Panao River above Panao.

Trujillo on the eastern side of the valley, some miles below Piedra Grande. On the western side of the Huallaga between Acomayo and Tingo Maria there are, I understand, coca plantations. A certain amount of timber, mostly eucalyptus, is also taken from this region for use in Cerro de Pasco.

The valley floor of the Huallaga at Huánuco is nearly a mile wide. As one proceeds down, it first widens a little then narrows into a gorge which continues beyond the big bend of the Huallaga at Piedra Grande. There are several small towns below Huánuco; the largest of them is Panao, on the southeast bank of the river of the same name, a few miles above its confluence with the Huallaga. The town has a sub-prefecture and is in connection with Huánuco by telegraph. North of Panao and high up on the eastern side of the quebrada is the small town of Chaglla. This is the last outpost of the semi-dry agricultural zone. Within a few miles the montaña begins. There are no trees at Chaglla: potatoes and alfalfa are grown, and there is good coarse grazing grass. As soon as one begins to descend into the gorge to the north one passes through a belt of mixed trees and open grassland into drier

vegetation with cactus and, where there is cultivated ground, bananas, pineapples, and yucas. At the foot of the gorge cactus plants are the only form of vegetation.

The dividing line between the dry, pastoral sierra country and the wet, tree-covered montaña is the most striking feature of the region. The line is distinct, and the general direction parallels the main cordillera. Much higher than Chaglla and immediately to the east of the Huallaga gorge are the high peaks of the eastern range. Trees

FIG. 33—The Plaza, Huánuco.

cover them everywhere except where the bare rock protrudes a few hundred feet at the top and on the swampy, grass-covered pampa of Tambo de Vaca. The height of the tree line varies greatly from place to place.[10]

On the top of the range at Tambo de Vaca it rains nearly all the time except perhaps in April, May, and June: on the other side there is a delightful temperate zone at about 6000 feet. Again I observed our garden flowers—fuchsias and begonias, for instance—growing wild; and this country is a paradise for the butterfly collector. It was on the eastern slopes of the Tambo de Vaca range that we first came in contact with the well known German colony on the Pozuzo River—at the *hacienda* of Sr. Ballesteros at Cushi. Sr. Ballesteros was formerly an officer in the Peruvian army and has married into the colony. I mention him because he has settled in a rather different fashion from the rest.

## THE GERMAN COLONY

Some seventy years ago, encouraged by the Peruvian government, by the offer of free land, and by soil and climatic conditions reputed so

[10] Compare similar variation in the Urubamba Valley depending upon insolation as controlled by slope exposure and upon moisture controlled largely by exposure to winds (Bowman, *op. cit.*, pp. 71 *et seq.*).

FIG. 34

FIG. 35

FIG. 36

FIG. 34—A street in Huánuco.

FIG. 35—Looking north up a side quebrada from the main Huallaga valley several miles below Huánuco

FIG. 36—Looking east down Rio Huallaga from Huánuco. In the semiarid quebrada region. Compare Figure 39.

FIG. 37

FIG. 38

FIG. 39

FIG. 37—On the road between Huánuco and Acomayo.
FIG. 38—The center of the Pozuzo colony.
FIG. 39—Looking north down Rio Huancabamba three miles south of its confluence with the Pozuzo. The montaña region. Compare Figure 36.

favorable that anything might be cultivated, some hundreds of Germans, Catholic peasants from the Tirol and Rhineland, were persuaded to settle on the Pozuzo River near where it is joined by the Huancabamba. Eighty families arrived in 1857, a similar number some few years later. The population now totals about 600 persons. It is very much scattered, each family having its own farm. The center of the colony is not a town but simply consists of a church, a store, a school, and one or two houses. We had heard much in Huánuco about the degeneracy of the colonists, but our first impressions pointed in an exactly opposite direction. One cannot but be impressed on entering the colony by the main trail to notice the well constructed houses, well cultivated land, and the general aspect of tidiness. Picturesque suspension bridges have been built over the Pozuzo and the Huancabamba rivers; and the trails, after the wretched experiences we had endured on the other side of the mountains, seemed very well kept. It was surprising to meet, in such a situation, an extremely blond, beautifully complexioned girl cleanly dressed in white, walking down the trail and carrying a pail in each hand like the traditional Tyrolese milkmaid.

FIG. 40—A young woman of the German colony at Pozuzo.

The houses that we first visited near the center of the colony were those of the older generation, and one saw well made chairs, carved doors, religious pictures, family photographs, and every indication that the people loved their homes and were proud of them. The church had been almost entirely built by the priest himself, and there were two stained glass windows which had been brought from overseas. The colonists adhere closely to their religion, and one sees them all at church on Sunday. The children living near by attend the school four days a week; on the remaining days the school-teacher travels on muleback to an outlying district of the colony, there to teach the others. They are taught to speak Spanish, but they read the Bible in German.

These were our first impressions, and we saw Pozuzo as a veritable little paradise. However, we were inclined to be disillusioned later, though the state of affairs was by no means as bad as we had been led to expect. The great quantity of raw cane alcohol drunk by the

men has had a deleterious effect on the physique of the second and third generations, though there are still plenty of fine, upstanding people in the colony. The women seem very much more healthy.

The governor of the colony is an Indian, as it is against the constitution of the country that any one not Peruvian-born should hold this office, but the mayor is of German extraction; the priest is German-

FIG. 41

FIG. 42

FIG. 41—Women and children of the German colony at Pozuzo, established 70 years ago.
FIG. 42—Indians from the Puerto Victoria district at the junction of Pichis and Palcazu.

born, and he revisited his native land as recently as 1924. He has been with the colony for thirty years and, besides being the spiritual guide, is doctor, storekeeper, and what you will. Only two or three of the original colonists are now alive, but the old manners and customs are still maintained, and the styles in clothes are those, one gathers, of 1860. After church on Sunday the people gather round the little store, buying their simple needs from the priest. One notices a certain amount of Indian blood; but there has not been much intermarriage with the Indians: it has evidently been frowned upon.

There are many reasons why this colony has not developed successfully. The most obvious, no doubt, is its inaccessibility;[11] but the climate plays an important part. These Germans have been accustomed to a rigorous winter. The continual summer apparently has undermined their constitutions. The colony is situated at too low an elevation: the altitude is only 2800 feet. Sr. Ballesteros lives in the really healthful zone at 6000 feet. Moreover he has made the Indians work for him. The Germans have not done so.

[11] Otto Nordenskjöld: Sudamerika: Ein Zukunftsland der Menscheit, Stuttgart, 1927, pp. 196–197.

## Communications with the Amazon: Puerto Leguia

Automobile road building is progressing in the upper Huallaga Valley region. There is quite a good road between Cerro de Pasco and Huánuco, and this already has been continued down the Huallaga Valley to Acomayo, whence a branch is being constructed across the hills to Panao. Other short sections of road are in existence from Huánuco to the west, and a road is being built from Goyllarisquisga into the Yanahuanca quebrada, where excellent trails exist. It is only when one approaches the montaña that poorer trails are encountered. The principal route between Lima and Iquitos used to be via Huánuco and Pozuzo, along the Huallaga Valley to Muna and thence over the tops of the mountains in a more or less straight line to Pozuzo. Though not the easiest, it was the shortest route. When the road to La Merced was built the main route to Iquitos changed, and every one now goes by way of Tarma and La Merced. The old trail has fallen into disrepair, and the route to the colony is now fantastic in the extreme.

Various projects whereby Puerto Leguia on the Rio Pachitea is to be connected by road or railroad with Lima have lately been discussed. One of these schemes shows a route directly through Pozuzo. At present Pozuzo people wishing to go towards Iquitos travel by way of Chuchuras on the Rio Palcazu, to which place there is a moderate trail.

We took the old route by way of Puerto Mairo, which has been neglected for years and can hardly be called a trail any longer. Puerto Leguia is a recently established colony. It is sufficiently far down the Rio Pachitea to allow regular communication with Iquitos by small steamboats. An attempt was made two or three years ago to colonize it with Californian farmers, but very few of the hundred or more families stayed longer than three or four months. But Peruvians look on the place as a future port for communication between Lima, the sierra country, and Iquitos. In Lima I was told by the promoter of the Puerto Leguia colony that 60 miles of a new trail had already been cut across the Pampas de Sacramento from Puerto Leguia in a straight line towards the big bend of the Huallaga. If this trail is ever completed it will cross the mountain range at a much lower altitude than the old one and will form part of an admirable route between Lima and Iquitos. The chief advantage of this route, apart from its directness, is the fact that between the Huallaga and the Pachitea no streams of any considerable size have to be crossed.

At Puerto Mairo, Chuchuras, and Bermudez, where the trails end at present, all traffic is continued by water. The rivers in these regions are swift and liable to sudden rise and fall of many feet even in the course of a night. The mail boat coming up from Iquitos, drawing over four feet of water, often is compelled to stop at Puerto Victoria owing to the low state of river, and the journey is continued to

Puerto Bermudez up the Rio Pichis by canoe. It seems strange that no intermediate-sized craft has been used on these rivers. Nevertheless one of the main reasons given for the underdevelopment of this region is the difficulty of navigation.

Puerto Victoria lies at the point where the rivers Pichis and Palcazu join to form the Pachitea. Here is the trading station and comfortable *hacienda* of Sr. Walter E. Buttgenbach, who owns a large concession on the northern bank of the Palcazu as far as Puerto Mairo. He originally settled at Puerto Mairo but moved from there because of the terrific storms experienced in that neighborhood. At Puerto Mairo he traded with the people of Pozuzo and exported his produce to Lima. At Puerto Victoria he conducts all his trade with Iquitos.

FIG. 43—Working the radio set at Puerto Victoria.

No one now lives at Puerto Mairo except a Chinaman and his old mother; but there is a considerable population of Indians in the neighborhood, some of whom grow cotton which they sell to Sr. Buttgenbach. The Indians belong to three distinct tribes. In the Pozuzo-Puerto Victoria area live the Ammashes. They are partly civilized and are not particularly hardy. To the east of Puerto Victoria live the Campas, a virile race, not so much touched by civilization. In the Pampas de Sacramento to the northwest live the Cashivos, completely untouched by civilization. Sr. Buttgenbach has two or three Cashivo children working on the *hacienda* at Puerto Victoria. These children, found as small babies deserted in the forest, are pretty and intelligent.

Everything at Puerto Victoria grows with great rapidity. Yucas in six months sometimes grow single roots twenty-five pounds in weight. Sr. Buttgenbach was experimenting with the growing of ginger for export to Europe, but so far the crop had not progressed sufficiently for him to know whether it would be successful.

Sr. Buttgenbach's uncle, Herr Kurt Buttgenbach, formerly the editor of a German newspaper in Aachen and now living with his nephew, has been taking systematic meteorological observations here. Some of his records for 1925–1926 are published in Table I.

Puerto Victoria was as far east as we intended to go, and we returned to Lima by the way we had come, no further work being practical owing to sickness amongst the party and the approach of the rainy season.

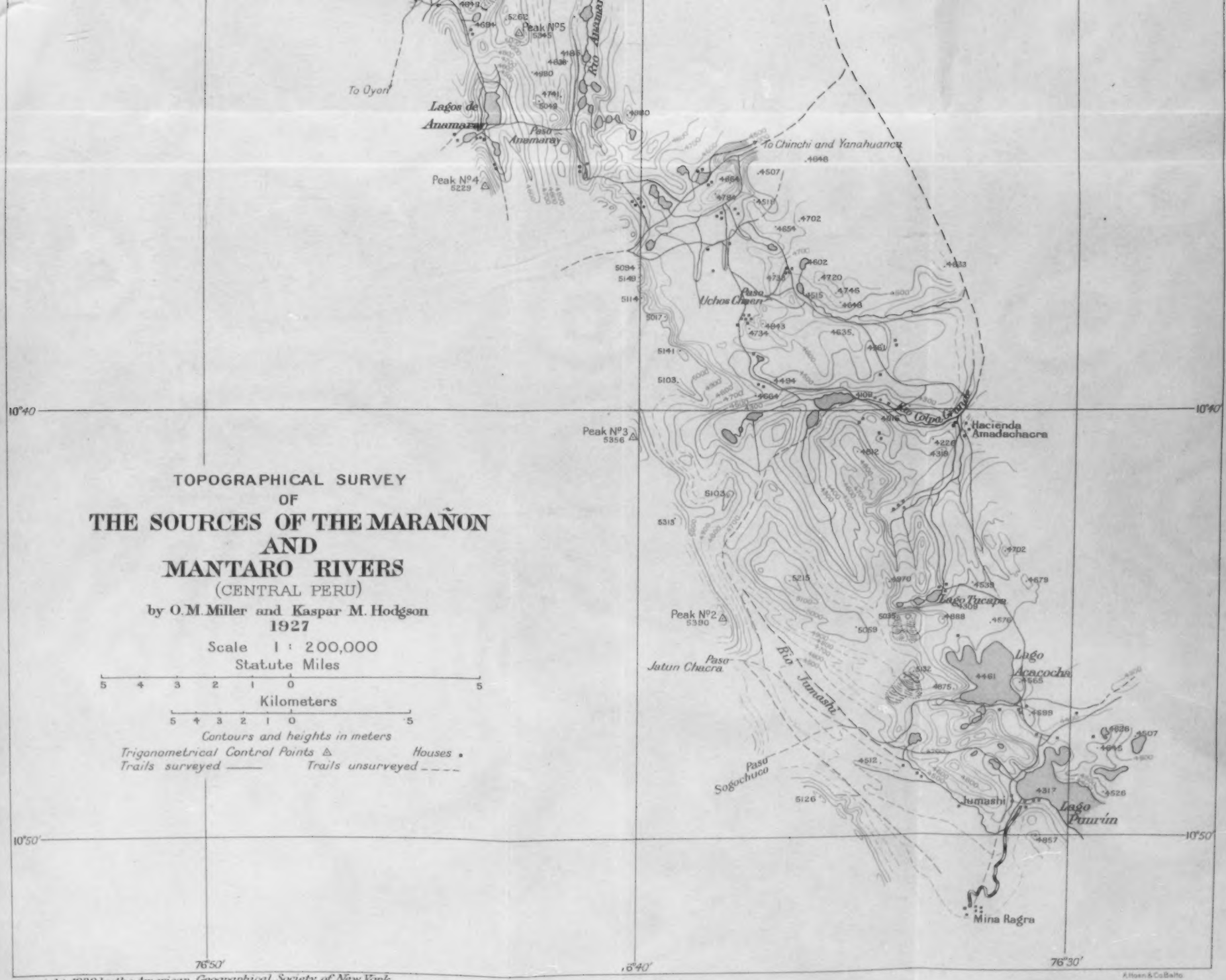
TABLE I—METEOROLOGICAL OBSERVATIONS AT PUERTO VICTORIA, 1925–1926

| | TEMPERATURE °C. | | | | | | | | RAINFALL IN MILLIMETERS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MEAN MONTHLY | | | ABSOLUTE | | DAILY RANGE | | | DAILY MEAN | | MOST IN A DAY | TOTAL |
| | MEAN | MAX. | MIN. | MAX. | MIN. | MEAN | MAX. | MIN. | 5.30 P.M. TO 6.30 A.M. | 6.30 A.M. TO 5.30 P.M. | | |
| 1925 | | | | | | | | | | | | |
| Nov. | 26 | 29.6 | 23.4 | 32 | 22 | 5.1 | 8.5 | 2.0 | 7 | 3.2 | 84 | 306 |
| Dec. | 26.5 | 29.1 | 23.8 | 32 | 22.5 | 4.2 | 8.5 | 0.5 | 2.5 | 3.5 | 92 | 186 |
| 1926 | | | | | | | | | | | | |
| Jan. | 26.9 | 29.8 | 24.1 | 32 | 21 | 6.1 | 9.0 | 4.0 | 2.5 | 2.0 | 30 | 139 |
| Feb. | 26.6 | 29.4 | 23.8 | 33 | 21 | 5.6 | 10.0 | 1.5 | 2.3 | 1.9 | 24 | 117 |
| March | 26.6 | 29.0 | 24.1 | 31.5 | 21 | 5.1 | 10.5 | 0.5 | 5 | 3.5 | 83 | 266 |
| April | 26.6 | 29.0 | 24.8 | 31.5 | 21 | 5.0 | 7.5 | 2.0 | 1.5 | 0.2 | 14 | 50 |
| May | 25.6 | 28.0 | 23.2 | 32 | 20.5 | 4.8 | 8.0 | 2.0 | 1.6 | 0.1 | 24 | 53 |
| June | 26.2 | 29.1 | 23.3 | 31.5 | 21 | 5.8 | 9.0 | 1.5 | 2.7 | 0.3 | 34 | 92 |
| July | 26.2 | 28.8 | 23.6 | 31 | 18 | 5.2 | 10.0 | 3.5 | 0.9 | 0.3 | 10 | 35 |
| Aug. | 26.4 | 30.1 | 22.7 | 33 | 21 | 7.4 | 10.5 | 0.0 | 0.1 | | 7 | 14 |
| Sept. | 27.9 | 32.2 | 23.6 | 34.5 | 21 | 8.6 | 11.0 | 0.5 | 0.7 | 1 | 21 | 52 |
| Oct. | 26.8 | 29.7 | 23.8 | 34 | 19.5 | 5.9 | 12.4 | 0.5 | 2.1 | 1.5 | 37 | 110 |
| Nov. | 26.1 | 28.2 | 23.9 | 31.5 | 21 | 4.3 | 8.0 | 0.5 | 6.7 | 4.7 | 82 | 342 |
| Dec. | 25.6 | 27.6 | 23.6 | 31 | 22 | 4.0 | 8.0 | 1.0 | 6.1 | 8.8 | 143 | 481 |

## THE PHYSIOGRAPHY OF CENTRAL PERU

The principal physiographic features of Central Peru may be understood by reviewing the photographs that illustrate the preceding narrative. Long-continued erosion upon complicated rock structures produced in times past a surface of little relief (Figs. 4–5). Parts of this surface are still well preserved with only moderate erosion following soil stripping (Fig. 4). Other parts are more deeply dissected (Fig. 5). A feature commonly found in the Central Andes—local alluvial fill merging into erosional surfaces in the intermontane areas—is well shown in Figures 6 and 7. The relation of the higher residual elements of the landscape to the lower and flatter elements of fill and erosion surface is most clearly shown in the contrast afforded by Figures 6 and 13 taken from the same station. The long lateral moraine that shows in the latter photograph marks the site of a huge glacier that descended from the high cordillera that here forms the Atlantic-Pacific divide. Glacial forms are among the most distinctive in the whole field of our survey. They are brought together and their relations to high mountain country and drainage lines shown upon the map, Plate I. Their detailed expression is best seen in Figures 12, 16, 17, 19, 24, 25. Moraines and U-shaped valleys with characteristic lakes, steep-walled cirques, hanging valleys, and other topographic discordances are abundant and are all disposed in natural relationship

76°50'
76°40'
76°30'
10°20'
10°30'
Peak Nº 18
6128
Peak Nº 17
6123
Peak Nº 16 (Carnicero)
6632
Peak Nº 14
6352
Peak Nº 13
6143
Río Nupe
Río Marañón
Lauricocha
Lago Lauricocha
3686
Yantac
Quebrada
Hacienda Antacallanca
Lago Patarcocha
Lago Negro
Lago Geyca
Lago Tinquicocha
Peak Nº 10
Peak Nº 9
5589
Mina Raura
Lago Caballococha
Lagos Porosi
Peak Nº 8
5717
Cerro Raura
Peak Nº 7
5660
Chinchi
Lago Aguinaga
Peak Nº 5
5345
Anamarca

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A. Hoen & Co. Baltto.

to the living glaciers of today that occupy the remoter mountain strongholds.

Upon the main valley floors, and below the scenes of active glacial scouring, are deposited the waste products delivered to the streams in the glacial period. Figure 35 shows this feature, and the pencil sketches illustrate other phases of it (Figs. 30–32). With the waning of the glaciers, and probably as a further result of recent uplift, the alluvial fill has been deeply eroded and in part reworked. The process is going on rapidly today. The alluvial forms are of special geographical interest because of the disposition of fields and pastures in conformity with them (Figs. 29 and 32). Toward the eastern border of the Andes the forms developed upon the fill, as well as glacial forms and pampa flats, give way to those associated with vigorous erosion under a heavy tropical rainfall with turbulent streams and steep mountain slopes marking the transition to lower valleys and plains.

## APPENDIX: THE SURVEYING AND ASTRONOMICAL WORK

The surveying instruments had been selected with regard to lightness of weight, as it was expected that this work would be done by only one man. The instruments are illustrated in Figure 46, and their weights are given in Table III.

The Wild theodolite was used for all the trigonometrical and astronomical work and proved very satisfactory. Unfortunately at one period the vertical circle went out of action, owing to a defect in one of the prisms, and had to be dismantled and reassembled in the field. This took considerable time; but, considering the reputedly complicated optical arrangement, it is remarkable that it was possible to get the instrument back into good working order again.

At Cerro de Pasco and Goyllarisquisga we used the Cerro de Pasco Company's triangulation stations and several of our own. The former were permanently marked by lengths of iron tubing stuck vertically into concrete. Datum level was taken from the Cerro de Pasco Company's bench mark at Cerro de Pasco station. A list of geographical coördinates and heights above sea level of the principal points fixed trigonometrically is given in Table III.

Most of the peaks in the above list may be identified in the line drawings (see Fig. 44). Peak No. 1 is a conspicuous Matterhorn type of peak to the southwest of Lake Punrún. Peak No. 2 overlooks the upper Jumashi Valley and stands to the west of it in the main cordillera. Peak No. 3 stands at the head of the Colpa Grande River. Peak No. 4 is a dome-shaped black peak on the Pacific side of the main cordillera close to the Anamaray Pass. Peak No. 23, as seen from Cerro de Pasco, appears as a curious-shaped knob, not very high, on the distant north horizon. Peak No. 24 is an isolated mountain to the north. Peak No. 25 is one of the last snow-capped peaks to the northeast of Cerro de Pasco. It is the highest and most conspicuous peak in this direction. Peak No. 34 is the most conspicuous peak as seen from Cerro de Pasco to the south of Peak No. 1 in the main cordillera. Station No. 1 at Cerro de Pasco is a temporary station on a hill to the northeast of the town. It was not permanently marked. Stations 2 and 3 were triangulation stations in the Cerro de Pasco Company's own survey. At Goyallisquisga, Stations 38 and 39 were Stations G1 and M2 in the Company's triangulation at this latter place.

The astronomical station at Huánuco was in the back courtyard of the Hotel Inca. The station at Tambo de Vaca was on the main trail where a small trail from

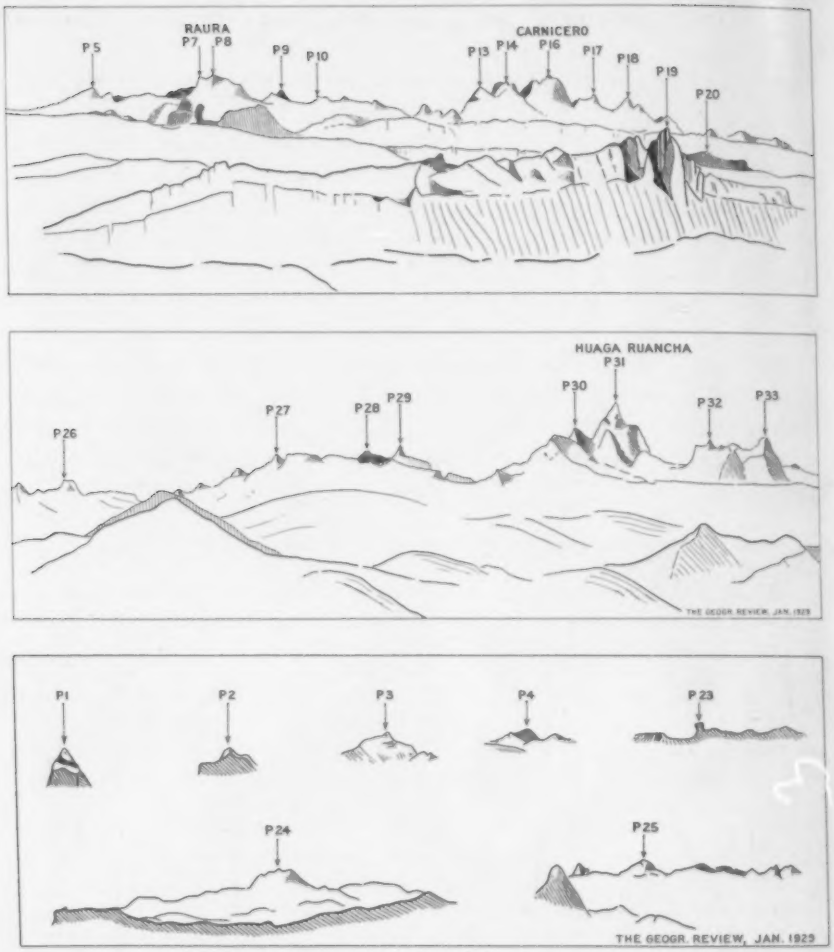


FIG. 44—Sketches from Station No. 1, Cerro de Pasco. The top panel is looking northwest; the middle, looking east; the bottom panel is for the identification of individual peaks.

the northeast joins it. The station at Cushi was 200 feet to the east of Sr. Ballesteros' *hacienda*. The station at Pozuzo was in front of the church. The station at Puerto Victoria was about 100 yards south of Sr. Buttgenbach's *hacienda*.

It was difficult to know what coefficient of refraction to take at the high altitude we were working in: the figure eventually adopted was 0.050, which gave quite satisfactory results. The checks on the work at Goyallisquisga were sufficiently good, considering that the intersections were made on the tops of unbeaconed peaks. The astronomical method employed for determining latitude and longitude was the Marc St. Hilaire method as adapted by John Ball for precise work on land. The observing for this method requires that the Greenwich time of observation be known very exactly, and this was possible as wireless time signals were received from Arlington a few hours before and after each set of observations. The latter consisted of a series of time and altitude observations taken on four or more stars of widely varying azimuths, at least four observations taken on each star. This method has many advantages over most of the other methods generally used in the field. Any star at

TABLE II—GEOGRAPHICAL COÖRDINATES AND HEIGHTS ABOVE SEA LEVEL OF SURVEY-CONTROL POINTS

| NAME OR NUMBER OF STATION | LATITUDE SOUTH | LONGITUDE WEST | HEIGHT ABOVE SEA LEVEL | |
|---|---|---|---|---|
| | | | FEET | METERS |
| No. 1 (at Cerro de Pasco) | 10° 39′ 05″ | 76° 15′ 08″ | 15,074 | 4594 |
| No. 2 (at Cerro de Pasco) | 10° 41′ 16″ | 76° 16′ 29″ | 14,285 | 4354 |
| No. 3 (at Cerro de Pasco) | 10° 41′ 33″ | 76° 15′ 15″ | 14,726 | 4488 |
| (S. E. Corner chimney C. de P. Co.'s office, Cerro de Pasco) | 10° 41′ 12″ | 76° 15′ 34″ | 14,261 | 4346 |
| Peak No. 1 | 10° 55′ 52″ | 76° 36′ 13″ | 17,756 | 5412 |
| Peak No. 2 | 10° 44′ 57″ | 76° 36′ 13″ | 17,683 | 5390 |
| Peak No. 3 | 10° 40′ 37″ | 76° 40′ 07″ | 17,572 | 5356 |
| Peak No. 4 | 10° 34′ 50″ | 76° 43′ 33″ | 17,157 | 5229 |
| Peak No. 5 | 10° 31′ 18″ | 76° 42′ 50″ | 17,535 | 5345 |
| Peak No. 7 S. E. Peak Raura | 10° 29′ 21″ | 76° 43′ 00″ | 18,570 | 5660 |
| Peak No. 8 N. W. Peak Raura | 10° 29′ 05″ | 76° 43′ 11″ | 18,755 | 5717 |
| Peak No. 9 | 10° 26′ 30″ | 76° 46′ 59″ | 18,336 | 5589 |
| Peak No. 10 | 10° 26′ 10″ | 76° 45′ 39″ | 18,173 | 5539 |
| Peak No. 13 | 10° 18′ 08″ | 76° 53′ 32″ | 20,156 | 6143 |
| Peak No. 14 | 10° 17′ 45″ | 76° 52′ 59″ | 20,839 | 6352 |
| Peak No. 16 (Carnicero) | 10° 16′ 01″ | 76° 54′ 09″ | 21,760 | 6632 |
| Peak No. 17 | 10° 15′ 00″ | 76° 54′ 02″ | 20,090 | 6123 |
| Peak No. 18 | 10° 14′ 06″ | 76° 54′ 08″ | 20,104 | 6128 |
| Peak No. 19 | 10° 37′ 39″ | 76° 17′ 17″ | 15,118 | 4608 |
| Peak No. 20 | 10° 33′ 08″ | 76° 23′ 40″ | 14,927 | 4550 |
| Peak No. 23 | 10° 12′ 24″ | 76° 30′ 20″ | 14,669 | 4471 |
| Peak No. 24 | 10° 11′ 23″ | 76° 24′ 21″ | 15,960 | 4865 |
| Peak No. 25 | 10° 02′ 49″ | 75° 59′ 12″ | 16,732 | 5100 |
| Peak No. 26 | 10° 22′ 47″ | 75° 57′ 34″ | 16,757 | 5107 |
| Peak No. 28 | 10° 30′ 27″ | 76° 00′ 15″ | 16,562 | 5048 |
| Peak No. 29 | 10° 28′ 43″ | 75° 56′ 25″ | 17,056 | 5199 |
| Peak No. 30 | 10° 31′ 38″ | 75° 56′ 30″ | 17,856 | 5442 |
| Peak No. 31 (Huagaruancha) | 10° 31′ 46″ | 75° 55′ 44″ | 18,797 | 5748 |
| Peak No. 32 | 10° 33′ 07″ | 75° 56′ 16″ | 16,804 | 5122 |
| Peak No. 33 | 10° 33′ 53″ | 75° 56′ 21″ | 16,930 | 5160 |
| Peak No. 34 | 11° 08′ 54″ | 76° 30′ 03″ | 17,616 | 5369 |
| Station No. 38 (at Goyllarisquisga) | 10° 28′ 04″ | 76° 24′ 22″ | 13,955 | 4253 |
| Station No. 39 (at Goyllarisquisga) | 10° 29′ 22″ | 76° 24′ 45″ | 13,984 | 4262 |
| Huánuco | 9° 55′ 27″ | 76° 14′ 12″ | (6,397) | (1950)* |
| Tambo de Vaca | 9° 52′ 03″ | 75° 45′ 37.5″ | (11,384) | (3470) |
| Cushi | 9° 58′ 27″ | 75° 41′ 40″ | (6,233) | (1900) |
| Pozuzo | 10° 03′ 42″ | 75° 32′ 43″ | (2,789) | (850) |
| Puerto Victoria | 9° 53′ 23″ | 74° 56′ 27″ | (984) | (300) |

*Figures in parentheses indicate approximate heights.

any altitude can be observed and, whether identified or not at the time, can be used later. Consequently, if observing conditions are bad and it is possible to get only occasional glimpses of stars, useful observations are still possible.

It is not necessary to have the theodolite in perfect adjustment for vertical collimation. It is not even necessary to know the collimation error, as this is determined automatically by the computations later. It is not necessary then to change face on the instrument while observing, and consequently a series of observations on one star can be taken very rapidly. The writer averaged just over a minute in the time he took to make and record a single observation.

Comparing it with the equal-altitude method, it must be admitted that each single observation of altitude on a star is probably more accurate by the equal-

altitude method; but at least four, generally six, observations are taken on each star by the Marc St. Hilaire method; and in this way personal error is more or less eliminated, and not so many stars need be observed to obtain the required accuracy. No star lists are necessary. It is not necessary to carry mercury to provide an artificial horizon. Fewer stars observed means less computation. No program of work is necessary.

An example of this method is shown and, in the writer's opinion, is convincing proof of its efficacy. The station was over 11,000 feet high. There had been very heavy rain for two days. The mist cleared off for a short time only. In that time, 45 minutes, five stars were observed, at least four altitudes on each star being taken. It clouded over immediately afterwards, and further observation was impossible; but, as will be seen from the diagram of the plotted position lines, all the required precision was obtained, the probable error being about 0.6″ of arc. I do not think that on many occasions this degree of accuracy has been obtained in such a short time and with such light instruments.

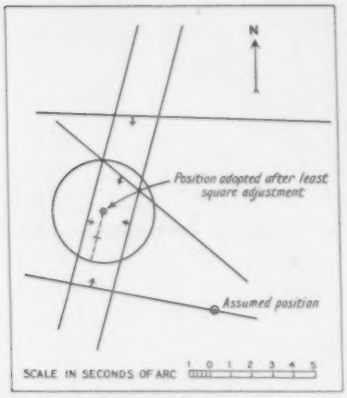


FIG. 45—Diagram illustrating accuracy of astronomical method. The observations were taken at Tambo de Vaca on November 9–10, 1927. The probable error in the adopted position is 0.6″ of arc.

The reception of the time signals was one of the important results of the expedition. It was amply demonstrated that there should be no difficulty in the future in sending small parties out to determine longitude and that there is no longer any necessity of carrying heavy equipment or employing radio experts on expeditions of this nature. The wireless instrument, which weighed only twenty-five pounds, was a long-wave receiving set, constructed for the expedition by the "Radio Broadcast" Research Laboratory, being the fourth constructed by them for the American Geographical Society. The first was successfully used by Mr. Reeves in Venezuela, the second by Mr. Weld Arnold in Gautemala, and the third by the Putnam Baffin Island Expedition. However, such is the rapid improvement in radio construction that, at the moment of writing, it is possible to get a short-wave receiving set which will pick up time signals from all over the world and which weighs, including batteries, about twelve pounds.

With the long-wave set there was at first some difficulty in getting time signals from Arlington; but, by what seemed to be unscientific manipulation of the lead to the ear phones and the lead to the aerial, we were eventually able to get these time signals where and when we wanted. The manipulation consisted in having a loose length of the lead to the aerial bunched up in one hand and bringing it into close contact with the lead to the ear phones.

The watches behaved well. They had small carrying rates most of the time, which was due in part to the method of carrying. Each watch was enclosed in a chamois leather pouch which in turn was shoved tightly into a leather pouch. This prevented a great deal of unnecessary shaking. The pouches were always carried on the belt.

To avoid the trouble of having to mount plane table sheets in the field, the system developed by the writer in 1924 at the School of Surveying of the American Geographical Society was used. This consists of a plane table framework which can be screwed down onto a Johnson plane table movement tripod head. Six specially prepared sheets of very thin aluminum on which good quality drawing paper had been mounted were carried in wax paper envelops. To set up the plane table for use

the framework is screwed onto the tripod head, and one of the aluminum sheets is then fixed onto the framework by means of specially constructed thumbscrews which do not protrude above the surface of the paper.

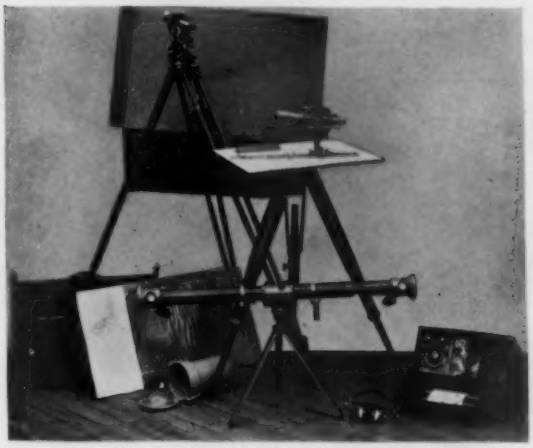

FIG. 46—The surveying equipment of the expedition. Compare Table III.

The range finder was a novelty in the way of instruments which proved very useful, solving the problem of locating points difficult of approach which could be seen from one station only, and doing away with the necessity of a stadia rod and rodman. The Barr & Stroud instrument has been very sturdily built as it is designed for use in warfare. This in itself is an advantage, but for surveying purposes the writer considers that it would be advantageous to have the adjusting screws that correct the halving and centering errors more easily accessible and more sensitive. It was always difficult to keep the instrument in adjustment, but this trouble was overcome by the following process. The distance between the observer's station and any point as determined by the range finder was corrected by comparison between the distances determined from an already fixed point as obtained from the plane table and as read by the range finder. A small sliding scale of tangents was constructed which greatly facilitated this process.

TABLE III—SURVEY INSTRUMENTS CARRIED BY THE EXPEDITION WITH THEIR WEIGHTS

| | |
|---|---|
| 1 Wild theodolite and tripod | 26 lbs. |
| 1 wireless receiving set, including batteries | 25 " |
| Watches—1 Ditisheim, 1 Zenith, 1 Leroy, 1 North stop watch, 1 Huguenin stop watch | 4 " |
| 1 plane table tripod with Johnson movement head | 10 " |
| 1 aluminum plane table framework 24" x 18" (American Geographical Society model); 6 plane table sheets mounted on aluminum enclosed in oiled paper envelops (the whole complete in canvas case) | 16 " |
| 1 Kern telescopic alidade in leather case | 12½ lbs. |
| 1 Barr & Stroud range finder | 16 " |
| 1 steel tape, 100 meters | 5 " |
| 1 Gurley geologist's compass and Jacob's staff | 4 " |
| 1 Brunton compass and clinometer | 1 " |
| 2 aneroid barometers | 3 " |
| Thermometers | 1½ " |
| Record books, mathematical tables, textbooks, miscellaneous stationery, and drawing materials | 22 " |
| Total weight | 146 " |

# THE INDIAN COUNTRY OF SOUTHERN ARIZONA

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IN Arizona, as in no other of our states, the Indian has maintained his hold upon the land. In numbers of pure-blooded Indians the state leads with over 46,000 of the nation's 355,000,[1] while over considerable parts of the area primitive cultures hold sway. The white population has infiltered itself into the region on a pattern largely indicative of the areas and zones originally unoccupied or of sparsest Indian population. Only the barren desert wastes immediately to the east of the lower Colorado River have been shunned by both Indian and white. Phoenix, the present metropolis, with the great oasis lying about it is contiguous with the relatively closely knit Pima communities but occupies the lands upon which the Indians were unable to apply water. Tucson, the second largest city and earlier metropolis, occupied a zone between Papagos and Apaches—a part of the Papago territory untenable on account of Apache raids. In northern Arizona the important settlements have grown up along the Santa Fe Railway which succeeded the old Santa Fe trail, proceeding in part through a neutral zone between hostile Apaches to the south and Navajos to the north.

The Indian population of Arizona remains distributed much as it was before white settlement. The present day reservations include the most important areas of Indian occupation, though considerably restricted, especially in the case of the hostile Apaches and Mojave Apaches. For convenience of treatment the Indians of Arizona may be divided into two groups: the southern tribes who occupy the drainage basin of the lower Colorado River and chiefly that of its one important branch, the Gila, and the northern tribes who occupy the drainage basin of the middle Colorado and its chief branch, the Little Colorado. This article aims to give a sketch of the southern group of tribes.

## Pimería, Land of the Pimas and Papagos

The name "Pimería" was applied by the Spaniards to the territory occupied by the Pima and Papago Indians, that part which is now

[1] If mixed-blood Indians are included, Oklahoma leads with some 120,000; but, whereas the Indian population of Oklahoma is only 29 per cent pure Indian, that of Arizona is almost 99 per cent pure. New Mexico ranks third in both full-blood and in total Indian population (Extracts from the *Ann. Rept. of the Secretary of the Interior relating to the Bur. of Indian Affairs*, 1927). Compare H. J. Spinden: The Population of Ancient America, *Geogr. Rev.*, Vol. 18, 1928, pp. 641–660.

in Arizona being called Pimería Alta in distinction to the Papago country of Sonora, Mexico, Pimería Baja. The Arizona Pimería, so designated, is nearly coincident with the physiographic division known as the Basin Range Province, excluding the lands adjacent to

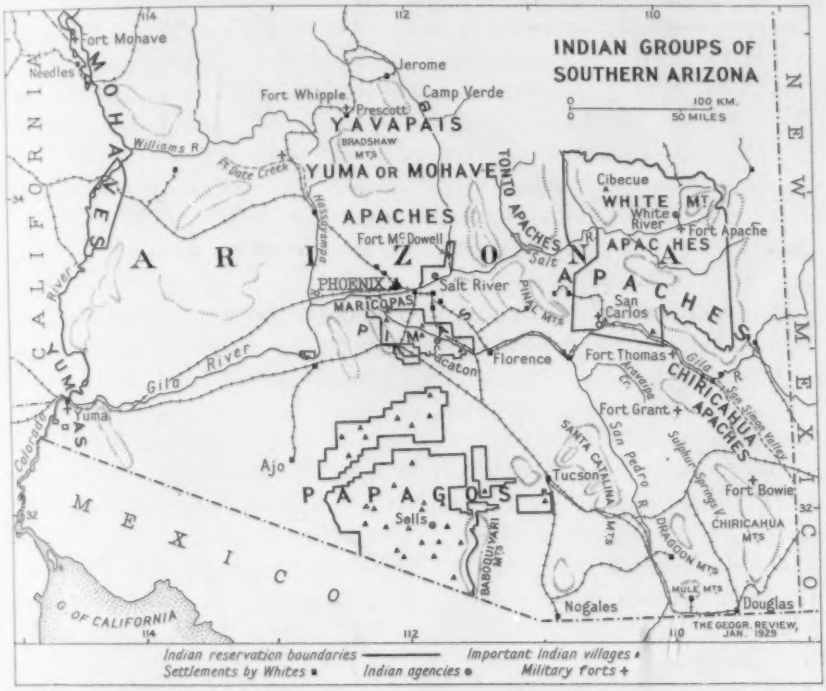


FIG. 1— Map showing the general distribution of the most important Indian groups of southern Arizona. The scale is a little less than 1:5,000,000.

the Colorado River and the unoccupied desert between the Colorado and the Gila rivers.

The Pimería is an arid country with well eroded fault block mountains rising between broad waste-filled intermont depressions. In the lower parts of the depressions, farthest from the mountains, sand and gravel washes traverse flat silt lands which have a surface veneer of coarser material. Nearer the mountains the land rises in long gentle alluvial slopes of sandy soil, known as the *bajada* slopes. Still nearer the mountains the bajada becomes gravelly or stony. Finally rock floor is exposed in the washes, revealing the mountain pediment, a subaerial extension of the mountain block protected from denudation. The general axis of surface features is northwest by southeast. The interlacing intermont plains rise imperceptibly from an elevation of several hundred feet in the west to over 2500 feet in the east and northeast. Out of them rise abruptly the low narrow mountain ridges, bare and harsh. In the east the mountains are most

massive and elevated, reaching the greatest height in the Baboquivari Range and its peak with an elevation of 7741 feet.

The outstanding climatic facts of the Pimería are the low and erratic rainfall, averaging about ten inches on the inhabited plains, accompanied by a very high rate of evaporation; the extremely high summer temperatures, very frequently rising above 100° F., and mild winters with temperatures seldom below freezing except in the higher parts; the marked daily range, often over 30° or even 40° F.; and the high percentage of sunny days averaging from 320 to 350 for the year.[2] In other words, the region has a desertic type of climate.

In the west the Pimería is truly a desert, but farther east with more rainfall the vegetal aspect is rather steppelike. The vegetation is nevertheless highly xerophytic and is characterized by peculiar and striking forms.

The Pimas and Papagos who occupy the Pimería are about equal in numbers; but the Pimas, having occupied the best lands on the flats along the Gila and Salt rivers near the present city of Phoenix, have required only a fraction of the area that has been required for the support of the Papago population.

The Pimas were able to divert water from the rivers upon the flood plains and became definitely settled as agricultural village dwellers. Their situation on the northern border of the Pimería exposed them to the raids of their mountain neighbors. Constant danger prevented them from scattering, and under pressure of necessity they became valiant warriors. They performed invaluable services to the whites during the turbulent periods of the Apache wars, furnishing protection to the pioneers and supplies to travelers. "Their regular fields, well-made irrigating ditches, and beautiful crops of cotton, wheat, corn, pumpkins, melons and beans, have not only gladdened the eye, but also given timely assistance to the emigrants who have traversed Arizona on their way to the Pacific."[3]

With fairly certain crops, the Pimas never learned to provide for lean years as did their kinsmen of the south who led a more precarious existence. The Papagos are more industrious and are much preferred as laborers to the Pimas. They are more ready to seek remunerative employment than the Pimas, although much more remote from sources of employment. Until about 25 years ago, the Pimas allowed the Papagos to come to their villages and thresh their wheat for a share. The practice is still carried on to a certain extent.

The area occupied by the Pimas, mostly in the Gila River Reservation, extending about fifty miles along the river, possesses natural

[2] See, for example, the meteorological summary for Sacaton in C. J. King and A. R. Leding: Agricultural Investigations at the United States Field Station, Sacaton, Ariz., 1922, 1923, and 1924. *U. S. Dept. of Agric. Dept. Circular No. 372*, June, 1926.

[3] Sylvester Mowry: Arizona and Sonora, *Journ. Amer. Geogr. and Statist. Soc.*, Vol. 1, 1859, pp. 66–75; reference on p. 70.

advantages which have from remote times made it a focal area for agricultural peoples. When first known by the whites, more than two hundred years ago, the Pimas had already occupied these lands at least several hundred years. For seventy miles along the Gila as well as along the Salt River are scattered the remains of the culture of a people much older and farther advanced. The land of the Pimas, including the Salt River plain, has in the past supported denser populations than any other part of Arizona.[4] This is true today of the Salt River plain and would be true also of these lands along the Gila had they been given equal opportunity of development. The Indian population was here dense enough to maintain its hold upon lands coveted by the whites.

The several hundred Pimas who live on the north side of the Salt River settled there at the suggestion of white settlers around Tempe, who sought thus to place a buffer between themselves and the Apaches. Later these same people requested the government to return the Indians to the Gila Reservation; but the request was denied, and their lands were designated as the Salt River Reservation.

A third branch of the Pima family, the Sobaipurai, in early Spanish times occupied the Santa Cruz Valley and even the San Pedro Valley to the northeast on the other side of the Santa Catalina Mountains. As far as we know, they are to be distinguished from the Pimas and Papagos only geographically. Later they were driven westward by the Apaches, and it is supposed their remnants joined the Pimas and were absorbed by them.

## The Gila River and Its Changed Character

The Gila River leaves the mountains to enter upon the detrital plains of the Basin Range Province about ten miles east of the city of Florence. Throughout its lower course it has incised a very shallow valley into the detrital plain. It is here a braided stream occupying a strip from a quarter of a mile to nearly a mile in width: the whole of its channel or any considerable part of it is occupied only occasionally after heavy rains. The channel is pretty well filled with shifting sandy deposits where only clumps of arrow weeds and low shrubs manage to get a hold here and there.

The Gila has changed greatly in character within the last half century. Old settlers are united in describing the Gila of fifty years ago as without shifting braided channels. Cottonwood, brush, tall grass, and weeds bordered the river, which was confined to a narrow channel. In the fall of 1849 a family and two other men floated down

[4] Walter Hough: Antiquities of the Upper Gila and Salt River Valleys, *Bur. of Amer. Ethnology, Bull. 35*, 1907.
Frank Russell: The Pima Indians, *26th Ann. Rept. Bur. of Amer. Ethnology for 1904–1905.*
Omar A. Turney: The Land of the Stone Hoe, Phoenix; see especially pp. 5–28.

FIG. 2

FIG. 3

FIG. 4

FIG. 2—Gila River, looking northwest from the Sacaton bridge.

FIG. 3—Typical Pima home evolved from the primitive "ki." The arbor, which was formerly placed somewhere near the "ki," has here become an adjunct of the house.

FIG. 4—View from terrace over Pima grainfields. In the background are the cottonwoods of the bottoms, and Gila Butte is seen on the other side of the river.

FIG. 5

FIG. 6

FIG. 7

FIG. 5—The upper terrace at Snaketown. Note the settlements on the upper terrace and the change in vegetation—salt bushes above and mesquite below.

FIG. 6—Terraces of the Gila River as seen from San Carlos, Apache Indian Reservation.

FIG. 7—Apache Indian village, near the Coolidge Dam site, San Carlos Indian Reservation.

the Gila from the Pima villages to the Colorado River on a flatboat 16 feet long and 5½ feet wide.[5] This was the period when river boats sailed from the Gulf of California through the delta and up the Colorado River. The channels of the delta of the Colorado have long since silted beyond possibility of navigation;[6] and the Gila, if not dry or very low, is in flood with current too swift for boats.

There is little similarity between the river of these descriptions and that of today; yet that portion of the Gila below the railway bridge at Pima Butte is perennial, and the waters except when high are clear. The perennial flow of the river here is primarily due to underground drainage deflected from the Salt River.[7] There is also some extra seepage from the Roosevelt irrigation project.

According to the old Indians on the reservation the river used to be everywhere constant, always supplying plentiful water for irrigation. Only in occasional very dry years did it cease to flow, and then large pools remained in the bed. Little distress was felt by the Pimas even in such years; but the Papagos to the south, whose water supply was less dependable, would then seek relief from the Pimas. As late as the seventies, and even during the eighties, the river occupied a narrow channel and its bed was covered with large stones. There were no such stretches of bare and sandy waste as are found everywhere along the river now. Tall grass, sometimes several feet high, covered the whole countryside yearly. But the once grassy swales are now for the most part salt bush steppe or desert. Lakes or ponds were once common over the river flats where there is no trace of them today.

The changes in the character of the Gila have reduced the Pimas of the middle and upper parts of the reservation to a system of agriculture relying upon the irregular flood waters for irrigation. Their circumstances have been particularly trying during the late few years of drought. At the lower end of the reservation there is always water in the river, and there is no real want; but the floods wash out the dams and make diversion more difficult. However, whether there shall be water on the fields or not is chiefly a matter of industry.

The widening of the river channel still goes on. At Snaketown, north of the river near the center of the reservation, the river is rapidly cutting away land that has been under cultivation and that lies on the terrace. Near the pumping station on the north side of the river 7½ miles east of Snaketown, the river cut sixty feet into

[5] H. H. Bancroft: Arizona and New Mexico, 1530–1888 (History of the Pacific States of North America, Vol. 12), San Francisco, 1888, p. 487. See also C. P. Ross: The Lower Gila Region, Arizona: A Geographic, Geologic, and Hydrologic Reconnaissance With a Guide to Desert Watering Places, *U. S. Geol. Survey Water-Supply Paper 498*, Washington, 1923.

[6] Godfrey Sykes: The Delta and Estuary of the Colorado River, *Geogr. Rev.*, Vol. 16, 1926, pp. 232–255.

[7] W. T. Lee: Underground Waters of Salt River Valley, *U. S. Geol. Survey Water-Supply Paper 136*, Washington, 1905; reference on pp. 123–125.

the terrace the winter before last. In the upper Gila Valley, plane table survey indicated that from October, 1915 to September, 1916 the Gila River washed away a total of 990 fertile acres in the San Carlos Apache Indian Reservation and 1155 acres of lands higher up in the Safford Valley. In October, 1917, 400 more acres were washed out in the Safford Valley.

The changed behavior of the Gila is generally attributed to overgrazing in the Upper Basin. Before 1870 there were few cattle, but they increased rapidly after the settlement of the Apache Indian troubles that year. During the eighties there was a series of wet years with abundance of natural forage. The ranges built up rapidly, and overgrazing resulted. During the same period the mountains of the Upper Basin in southeastern Arizona were being rapidly stripped of their timber for use in the mines. The hills were barer than now, because with the advent of the railways better mine timber was brought in from the outside; but the cutting for fuel continued. At the end of this series of wet years came the disastrous flood of 1891. Before this, flood waters of the Gila merely spread out over the flats and irrigated them. Now with the banks of the river unprotected by brush and grass, the channel suddenly widened, and many good ranches along the river were cut out. Smaller branches of the river in the upper basin cut channels as much as twelve feet deep. On the desert deep channels appeared in what had been grassy swales.

On the other hand, Bryan[8] calls attention to the fact that such channel cutting has been general throughout the southwest and began as early as the sixties. He, with others, is favorably inclined toward Huntington's hypothesis of a slight change of climate toward drier conditions as decreasing the vegetation cover and promoting run-off with more rapid erosion. The erosive work of the flood of 1891 was greater than that of all the previous years of settlement in the basin; a reduced vegetation cover greatly aggravated erosion. The reservation area has suffered less than the lands above, partly because of the low relief of the plain, but also no doubt because there has been less cultural disturbance here. The only important recent topographic change has been the silting up of the river channel and consequent widening.

In addition to such possible general causes of change was the reduction of water on the lower Gila due to irrigation farther up the river. Serious deprivation of water on the reservation began with diversion in the Florence district immediately above the reservation. It began in the sixties and reached its climax in the eighties. The Florence district was in turn deprived of most of its water by diversion in the upper Gila Valley.

[8] Kirk Bryan: Date of Channel Trenching (Arroyo Cutting) in the Arid Southwest, *Science*, Vol. 62, 1925, pp. 338–344.

## The Terraces of the Gila River in Relation to Pima Culture

The sides of a well developed valley flat in the alluvial plain along the Gila are marked by terraces varying in height up to about twenty feet on the Gila River Reservation. The terrace is best defined on the north side of the river below Gila Butte and vanishes entirely east of

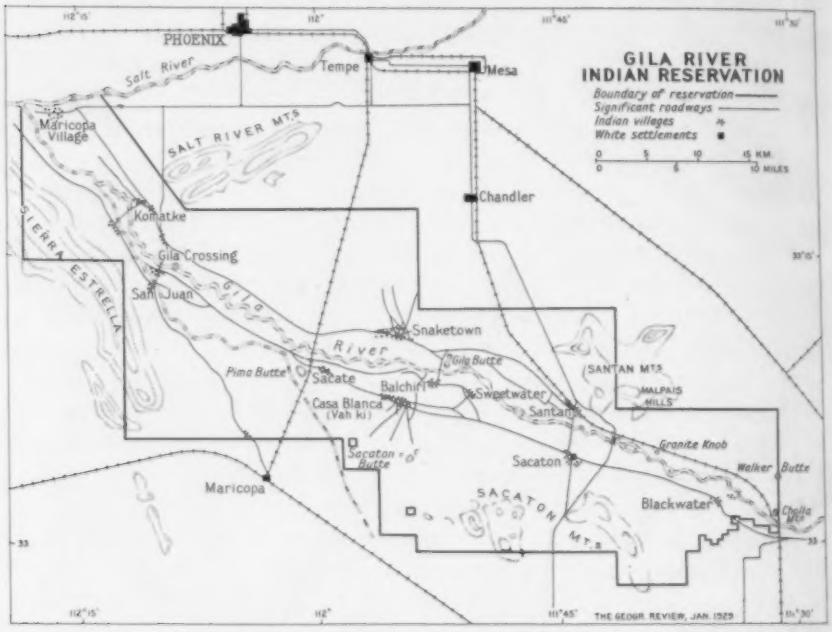


FIG. 8—Map of the Gila River Reservation. Scale approximately 1:750,000.

Gila Butte and around Sacaton. The flood plain reaches its greatest width of four miles between Casa Blanca and Snaketown, and the main river channel is nearly three miles from Casa Blanca.

Within this flood plain the river has cut an inner flat which confines all but the occasional master floods. It is bounded by lower terraces from three to ten feet in height. Over this flood plain the channel of the river varies considerably from time to time. For convenience we may speak of this low land bordering the river as the bottom land, the land on the outer flood plain as the lower terrace, and that above as the upper terrace.

The correlations of soil, vegetation, and culture are striking. The lands on the upper terrace are sandy with a veneer of gravel, while gray salt bushes mark it off distinctly from the bright green feathery foliage of the mesquite thickets so characteristic of the lower terrace where not cultivated. On the lower terrace the soil is silt and usually heavy. The bottom lands are sandy with an abundant mixture of silt. Cottonwood groves and arrow weed, a tall slender

reed, characterize the vegetation. Where the river is more stable or the ground is higher, the mesquite and salt bushes encroach upon the bottoms; but the cottonwoods and arrow weeds stop abruptly at the lower terrace, except that, wherever the lands are cultivated, cottonwoods take hold.

The cultural features of the reservation are as strikingly arranged with reference to the terraces as is the vegetation. Although the terraces are not indicated on the topographic maps of the Geological Survey, they can be traced fairly accurately by the cultural features as indicated.

The cultivated lands are limited strictly to the lower terrace, or terraces, where there is a further division of the terraces as at the villages Balchirl, Sweetwater, and Santan. The land under cultivation is further limited with reference to the possibility and ease of getting water on it. The villages are mostly located on the edge of the upper terrace overlooking the irrigable lands on the lower terrace. Up the river from Sacaton the upper terrace is not apparent as a topographic feature except for the characteristic vegetation association. Sacaton and Blackwater as well as the small villages between them are not definitely located with reference to terraces; but before white settlement there were no Pima villages in the upper end of the reservation. Sacaton itself was not an Indian village to begin with but developed around the government school.

The villages of the prehistoric people who occupied the area were distributed similarly to the villages of today. On the reservation, the most conspicuous of these ruins is that of the pueblo at Casa Blanca, now weathered into a huge mound. The largest cluster of mounds is directly across the river at Snaketown. The famed Casa Grande Ruin, just off the reservation to the southeast, is in a much better state of preservation. Some of the canals of the Hohokams, as these early people are called by the Pimas, extended onto the upper terrace lands, which they evidently cultivated in part. None of the upper terrace lands have been reclaimed by the Pimas; the ancient population was probably denser and certainly more advanced in technique and social organization. The river may also have been at a slightly higher level than now.

A main traveled road connects the villages all the way along each side of the river, following quite closely the edge of the upper terrace, where it is sandy enough to dry out readily, and is generally smooth. If a spot becomes rough it is simply avoided, and a new track develops around it. Many roads, if such they may be called, radiate from the villages onto the upper terrace lands called the "mesas." On the lower terraces the roads become deep sticky mud after rains; and later this bakes hard and rough, very dusty when dry. Through the cultivated lands they now run in straight lines and at right angles

conforming to the plotting of the land allotments by the United States Indian Service. Before the advent of the Southern Pacific Railroad the old transcontinental stage road followed the terrace route through Casa Blanca and Sacate. Wherever the lower terrace is wide and at least partially under cultivation a secondary road generally follows in the main the terrace bluff.

Several reasons suggest themselves for the preferred siting of the villages on the upper terraces. The drainage is better, and there is safety from flood. According to the Indians, the waters of the Gila twice since 1890 rose over the lower terrace and covered it to Casa Blanca. Communication has always been easier along the upper terrace, and better protection was afforded against hostile attack as here the enemy could be sighted from afar. The low mesquite thickets near the river were certainly much less desirable for homes than the open upper terrace. Casa Blanca and Snaketown have especially attractive sites with unobstructed outlook for miles in every direction. The Indians may also have discovered that the upper terrace sites were more comfortable, being warmer in winter because the cold air at night drained to the lower levels and cooler in summer because more exposed to the breezes. As time goes on, however, the Indians are scattering more widely over their tilled lands on the lower terrace.

During the middle of the nineteenth century the Pimas were almost entirely concentrated in villages on the south side of the river, owing to the dangers from Apache raids. The Pima settlements then extended from a point about two and a half miles below Sacaton nearly to Pima Butte. Early in the nineteenth century, according to numerous accounts of travelers and explorers and old Indians,[9] they seem to have been more widely spread. With the settlement of the whites along the Gila and Salt rivers and the establishment of peace with the Apaches, the Pimas have again extended their settlements.

## Economic Conditions of the Pimas

The chief crops of the Pimas today are, in order of importance, wheat, corn, alfalfa, and cotton. Vegetables, as beans, squash, pumpkins, and melons are also grown. Pima squaw corn is a popular native variety as it flowers in 50 or 60 days after planting, making small demands upon irrigation water. Unless flood water is abundant, it often happens that the heavy irrigation preliminary to planting is all the water that the crop receives.[10] As ordinarily grown by the Indians it rarely produces more than 10 or 15 bushels an acre.

The old Indians had a method of cultivating their grain which the whites have not been able to improve upon under the same condi-

[9] Russell, *op. cit.*, p. 20.

[10] C. J. King: Crop Tests at the Cooperative Testing Station, Sacaton, Ariz., *U. S. Dept. of Agric. Dept. Circular 277*, 1923.

tions. A peculiar method of plowing in the seed left the surface rough and afforded some frost protection. The soil then crumbled with the first irrigation and did not bake. The Pimas divert their water from the river by brush dams, constructed with considerable labor, or sometimes by mere embankments of river sand or silt. There are usually five or more such dams in the river, but they are often washed out by floods. During the several past years the Indians in the middle of the reservation have had to depend largely upon cutting and selling mesquite wood. A man requires two or three days to assemble a load which he may sell for about $6.00. Then he must haul it 15 to 20 miles and peddle it, which takes two more days unless there is a prompt sale. With more plentiful water the Indians leave off wood cutting and go back to their fields. A few of the Indians, especially at Casa Blanca, own some scrub cattle from which they derive partial or entire support.

After a difficult political struggle, the Federal government in 1924 authorized the construction of a dam on the Gila in the mountain narrows below San Carlos, the object being to restore their waters to the Pimas and to reclaim other lands. Construction was begun some time ago, and water will soon be provided for that part of the reservation above the Arizona Eastern Railroad. With the completion of the project the flood menace will have vanished, and the bottoms will be cultivated. Much of the upper terrace lands will also be brought under irrigation. The Indians will generally move out upon allotments, and the original character and diversity of the landscape will give way to homogeneity of aspect.

### The Mohave Indians

The Mohaves in their manner of living are much like the Pimas, being another tribe of oasis dwellers, utilizing the low narrow flood plains of the Colorado River between Needles, Cal., and Yuma where they formerly planted their corn, beans, and squash in the river ooze as the spring floods ebbed. The largest single village is near Needles. The Mohaves have been considerably reduced in numbers, suffering from contact with the worst element of the pioneer whites. Tuberculosis is now making serious inroads upon them.

About 25 Cocopah Indians live similarly to the Mohaves on two tiny reservations within the Yuma Irrigation Project.

### The Papago and the Papaguería

Barring a single outbreak in 1871 the Papagos, like the Pimas, have always been friendly to the whites, with whom, however, in their isolated location, they have had much less contact. To the country at large the Papaguería has been a *terra incognita*, a waterless

land seldom visited by white men, a forbidding desert taking its toll of human life.[11] The region is becoming better known since the advent of the automobile, the opening up of the mining camp at Ajo with railway connections to the Southern Pacific, and an automobile road now being extended eastward from Ajo and westward from Tucson. Over most of the area the Papagos are still the only inhabitants except for a handful of Indian agents, traders, and teachers. Southward the Papagos and their country continue into Mexico with no definite southern boundary, as the Papago population merges into the Mexican population. The Growler Mountains mark the western limit of their territory, though formerly a few people known as the Arenos or Sand Papagos eked out a meager existence in the barren desert west of this feature.

A very low standard of living prevails among the Papagos; yet, in spite of adverse conditions, they are among the few of our Indians who have remained entirely self-supporting. Hardly any other Indians have had their area so little exploited by other people. Their very poverty has been their protection. Those who know them best speak highly of their virtues and regret that American schooling too often breaks down their racial traditions of virtue and honor.

Today, as always, scarcity of water has been the determinant in the life of the region.[12] The Papagos commonly migrated between two villages, the one located near a permanent water supply found locally around the base of the mountains, the other about their temporals or fields along the washes out on the plains or in the valleys. The practice still continues with many of the Papagos, especially on the western half of the reservation.

The water supply at the temporals, or summer rancherias, was obtained from surface run-off during the summer rains and retained in hollow basins called *charcos* which were made by digging out a depression and applying the earth to an embankment on the lower side. The water supply thus obtained became warm and stagnant and was shared by the animals, yet it had to serve all domestic purposes. Even the water supply at the winter villages was often to be had only by patient digging in the sandy washes on the mountain pediment, and then sometimes attained only drop by drop along a plane of contact between sand and stone till the labor, sometimes of hours, was rewarded by one or two gallons of water. Pumpelly, who traversed the region in the early sixties, describes the experience of a friend who reached such a well at a time when, after a succession of dry seasons, the Indians were dying of thirst. "He found a large

[11] Compare Godfrey Sykes: The Camino del Diablo: With Notes on a Journey in 1925, *Geogr. Rev.*, Vol. 17, 1927, pp. 62–74.

[12] Kirk Bryan: The Papago Country, Arizona: A Geographic, Geologic, and Hydrologic Reconnaissance with a Guide to Desert Watering Places, *U. S. Geol. Survey Water-Supply Paper 499*, Washington, 1925.

number of Indians digging recklessly, far below the surface, and following down the line of contact between sand and rock, in the vain hope of finding a few drops of water. In their despair, they undermined the high face of the sand, and it fell, burying for ever a number of the unfortunate creatures."[13] Every drop of water was carefully

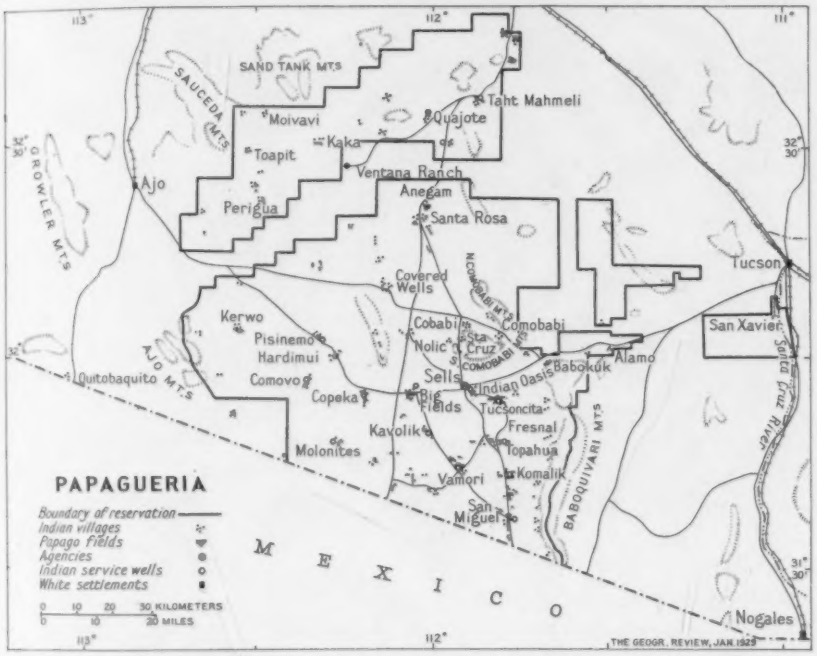


FIG. 9—Map of the Papago Indian Reservations. Scale slightly over 1 : 2,000,000.

conserved, even to the drippings from the olla, or earthen water jar, which might grow a couple of onions.

The desert scarcity of water had also its compensation in that it was the Papago's best defense against the marauding Apaches. By the middle of the eighteenth century the Papagos had been driven west of the Baboquivari mountain wall, except for a group about the San Xavier Mission under the protection of Tucson. But the approaches to their country west of the Baboquivari were carefully guarded, and the passes were the scenes of desperate battles.

The periodic intervillage migration is typically illustrated by the people of Kaka and Moivavi in the west-central part of the reservation, who together constitute a community of about 250 people. They are about the most isolated of the villages. It is only within the last year that the government has succeeded in getting the children from these villages to schools. Kaka is a typical rancheria village, the huts being scattered around the cultivated area. The fields lie on a flat

[13] Raphael Pumpelly: Across America and Asia, 3rd edit., New York, 1870, p. 38.

alluvial fan at the emergence of a canyon in low basalt hills which are outliers of the Sand Tank Mountains. The lavas almost surround the fan, and the houses are mostly located on this elevated land. The Indians assist nature in spreading over the fan the waters which pour down the canyon after the occasional heavy summer rains. There is no well here, the only attempt at drilling having encountered porous

FIG. 10—Storm clouds over the Baboquivari Range, Papago Indian Reservation.

basalt at no great depth. The Indians depend upon their *charco*, and formerly when it dried up they were compelled to leave or bring water from Moivavi 16 miles away in the mountains. Now a few remain and haul their water from the deep well on the Ventana ranch, six miles away.[14] When the water in the *charco* becomes low most of the Indians move up to Moivavi. The water here is obtained from a well in the bottom of a sandy mountain wash; the village is built on the small grassy flats above. The well, which is typical of the winter rancherias, is 32 feet deep and timbered but fills up whenever there is a heavy rain. Upon returning to Moivavi the first task is the laborious redigging of the well.

The movements between villages are timed with reference to the crops and the rains. The summer crops, chiefly squaw corn, beans, pumpkins, squash, and watermelons, are planted with the arrival of summer rains usually in July. If water is scarce, most of the Indians then go back to Moivavi to return for the harvest in October, after which they again go back into the mountains. Before the introduction of wheat the Papagos lived at their temporals only during

[14] The Ventana ranch grazes about 125,000 acres of land on "the strip" which was withheld from the reservation to give right of way for a railroad at the time under consideration from Tucson to Ajo. The writer is indebted to Mr. McKinney, owner of the ranch, for valuable assistance and information concerning the Papagos.

the summer months; but now wheat is the most important crop, and it is necessary for the Indians to come to their temporals for its sowing in December, January, or as late as February if the rains are delayed. It is usually harvested about May, and, as there are no rains at this time of the year, water must be hauled from the Ventana ranch.

FIG. 11—Babokuk, a typical Papago village in a cove of the Baboquivari Range. The bare, thorny-stemmed *ocatilla* is conspicuous in the foreground.

The Indians are effective agents in checking natural erosion as they spread the waters from the washes over their fields. Above the temporals or villages the washes may be deep erosion channels, while below they may not be at all apparent. Shallow ditches sometimes extend out from the fields for more than a mile to collect the surface run-off. But the rains are uncertain, and sometimes the crop must be reseeded, and sometimes there is no harvest. The bean crop in 1927 had to be put in three times on some parts of the reservation. If planted too near the washes, the crop may be washed out; if too far away, it may dry up. This year a dry spring was followed by a record-breaking rain, which washed out much of the seed planted for summer crops and made it necessary to replant. The spring drought resulted in an almost complete failure of the wheat crop except with the Kaka Indians who had the largest yield. The United States Indian Service has in late years dug a number of wells convenient to the temporals. Permanent villages have developed about these, but many of their people still migrate a great deal from one village to another.

A boon hardly second to the digging of wells was the introduction of cattle among the Papagos, and now they graze and sell many.

The Indians of the eastern part of the reservation have profited most from the cattle, having the better grazing lands. Before the late series of dry years many of them had become fairly well-to-do; but, in spite of abundant pasturage last year, there are only about half as many cattle as there were a few years ago.

The largest of the temporals is at Big Fields where a great block of land is under cultivation with the homes of the Indians scattered around the margin. Indians come here from several of the villages lying around the mountains, especially from Cobabi, Comobabi, Nolic, and Santa Cruz on the flanks of the Comobabi Mountains. A well has now been drilled by the Indian Service, and some people always remain. Similar scattered farming villages that have been given a degree of permanency by government wells are Topahua, Komalik, Vamori, Indian Oasis, and San Miguel west of the Baboquivari Mountains. Formerly these Indians had their winter rancherias along the Baboquivari Mountains. Now the population has become differentiated as a result of the influences emanating from the agency at Sells. Those living at the agricultural villages with government wells are the most progressive and wealthiest of the Papagos. On the mountain pediment and in the mountain coves at the old water holes are found the most conservative Papagos. They are largely dependent for a livelihood upon cutting mesquite wood and marketing it in Tucson, from 40 to 80 miles distant. Fully a week is involved in a transaction bringing about $6.00. In addition wagons must be kept up and horses fed on the long haul across the desert.

Santa Rosa, farther to the northwest, is the center of an area with about 3000 acres of cultivated fields. In 1920 about 200 tons of wheat was handled from Santa Rosa, and almost none has been handled since. In spite of a government well, drilled in 1915, the population varies from three or four families to as many as 700 persons. The digging of the well was protested by the Indians, for they believed that if the waters were once let loose they might not be controllable. Near Santa Rosa is a shrine where according to tradition the waters once flowed, threatening inundation of the country, and were only stopped when two children were thrown into the hole and it was covered with stones. The shrine is still religiously cared for and guarded, for should the stones be removed the waters would flow again. There is some ground for their superstitious fears: even this last summer, as in times past, Santa Rosa was almost washed away in the torrential downpour that followed the too successful rain-making *fiesta* and incantations of old "Doctor Lopez," medicine man and chief, who still reigns in the confidence of his people.

The people on the western part of the reservation, having the poorest lands, are themselves poorest; and in the summer many leave the reservation to seek employment in the cotton fields of the Salt

River oasis, nearly a hundred miles away. The journey both ways consumes about a week, and the season may be interrupted by a *fiesta* or two requiring return to the villages. But time enters little into the economy of the Papago.

Other migrations are occasioned by the religious *fiestas*. Each year many hundreds, especially from the western part of the reservation, cross the boundary on a pilgrimage to Magdalena, Mexico, and return for their *fiesta* flying the Mexican flag, while those at home go out with hands raised and palms out to meet those returning. They will save their money for months or even sell their cattle to be able to go to Mexico to celebrate at this time.

FIG. 12—"Doctor Lopez," medicine man, rain maker, and chief of the Santa Rosa Papagos.

## THE MOUNTAIN COUNTRY AND PEOPLES

The name Apache is frequently applied indiscriminately to all the peoples of the mountain provinces, as all depended in part upon raids for their subsistence and were the terror of the peace-loving plains tribes and later of the white settlers. The Yavapais, Yuma Apaches or Mohave Apaches, lived in a similar environment with the true Apaches and were similarly adjusted to it even to the building of their houses. They sometimes allied themselves with the Apaches for war purposes, but otherwise they remained distinct. Nor could the true Apaches be considered in any sense a nation. In spite of a common language, consanguinity, and the occupation of contiguous territory, most of the bands fought each other and lived in continual fear of reprisal. Their mountain environment prevented other than temporary unity. The Apache tribes were never all at once on the warpath, and from peaceful tribes were obtained the Apache scouts who rendered invaluable services in subduing their hostile *confrères*.

From the southeast corner of Arizona towards the northwest extends a series of roughly parallel mountain ranges with valleys between. This mountain province as related to the Indians may be divided into four subprovinces. The White Mountain region is located to the east. The Bradshaw Mountains with the surrounding

FIG. 13

FIG. 14

FIG. 15

FIG. 13—Moivavi, mountain village, Papago Indian Reservation. The Indians from Kaka move here when their water supply becomes low (see Fig. 16).

FIG. 14—Primitive "ki" at Quajote, Papago Indian Reservation.

FIG. 15—Typical Papago rancheria, Big Fields, Papago Reservation. Cultivated fields in background.

FIG. 16

FIG. 17

FIG. 18

FIG. 16—*Charco* at Kaka in early April, 1928—a dirty mudhole from which comes the water for all domestic purposes as well as for the animals.

FIG. 17—Vegetation near the Comobabi Mountains. Thorny cholla cactus and the low sagelike Franseria in foreground; *Sahuara* (giant cactus), cholla, *palo verde*, and ironwood in background.

FIG. 18—Cobabi, a piedmont village, Papago Indian Reservation. Typical mountain pediment vegetation in the foreground. *Sahaura*, *ocatilla*, and *palo verde* are conspicuous.

lower mountains are another distinct group to the west. Between the two groups extend long mountain blocks as the broken-down border zone of the Colorado Plateau. The intermont depressions, or structural valleys, are narrow in the north but widen to the southeast where they are also lower. A fourth subprovince may then be indicated to include the broad southern blocks, both elevated and depressed, as the Chiricahua Mountains, the Dragoon and Mule Mountains, San Simon Valley, and upper Gila Valley, Sulphur Springs Valley, and the San Pedro Valley. The Indians were grouped with reference to these mountain subprovinces, occupying the mountain valleys at the headwaters of the Gila and Salt rivers with their branches.

The mountain region is not only more rugged than the Pimería but differs also in climate and vegetation. The valleys average over 3000 feet in elevation, and the mountains generally rise more than a mile. The White Mountain province is all over a mile high and varies up to 11,000 feet. This area is in reality a subprovince of the Colorado Plateau, but the eastern part is made mountainous by numerous volcanic cones, and the western part is made rugged by the numerous canyons cut through horizontal lava beds by the headwater streams of the Salt River.

The rainfall varies from 15 to 25 inches, being greatest in the White Mountains. Some of the wider valleys in the south, with less than 15 inches of rainfall, are quite arid. The winters are to be reckoned with; in the higher areas, like the White Mountains, they are fairly severe, and the communities are isolated by the heavy snowfall. The higher mountains carry pine forests with scrub oak dominating their flanks. The broad lower valleys are semidesert, and the higher ones grassy if not scrub.

The Apaches, including the Mohave and Yuma Apaches, formerly consisted of four main groups distributed according to the four mountain subprovinces as outlined above.

The White Mountain Apaches lived in the narrow valleys along the swift-flowing streams on the Salt River watershed in the White Mountains. The chief center of population was along the White River, where the agency is now located. The Tonto Apaches lived in the Tonto Basin and the narrow valleys tributary to it. A separate group occupied the valley of the Cibecue Creek farther east. The Chiricahua Apaches lived around the Chiricahua Mountains and the San Simon and upper Gila valleys. They also roamed over the Sulphur Springs and San Pedro valleys and were the most troublesome of the Apaches and the last to be subdued. Before and after white settlement in the adjacent areas they made frequent raids into Mexico. A minor group, the Aravaipa Apaches, were located along the stream of that name and at its junction with the San Pedro

River. All these people were later confined to the San Carlos and Fort Apache or White Mountain reservations. The San Carlos Apaches now live along the San Carlos River and that part of the Gila on the reservation. The chief centers of Apache population are at San Carlos, where the agency is located, at Bylas on the Gila, and at Rice on the San Carlos River.

The Mohave and Yuma Apaches lived around the Bradshaw Mountains in the narrow valleys of the streams flowing south to the Salt or Gila rivers; also in the valley of the Verde River to the east. The Verde Valley reservation is the only part of their domain reserved to them, most of them having been removed to the Apache reservations. About 200 of them now live in the lower Verde Valley, and about 400 in the upper Verde Valley around Camp Verde.

Military forts were distributed among the hostile mountain peoples. Fort Whipple and Fort Date Creek near Prescott and Fort McDowell on the Verde were located in the midst of the Yuma and Mohave Apaches, though the last fort served also as a base of operations against the Tonto and White Mountain Apaches. Fort Apache was located in the midst of the White Mountain Apaches; and Fort San Carlos and Fort Thomas on the upper Gila, Fort Bowie at Apache Pass, and Fort Frank in the upper San Simon Valley were bases of operation against the Chiricahua Apaches.

The Apaches in common with nearly all the southwestern tribes usually chose to camp on a terrace somewhat removed from the water. The higher site was better capable of defense, but the principal reason was that the bottom lands are hotter in summer and colder in winter than the terraces above.[15] They subsisted in part by primitive agriculture in the mountain valleys, producing the usual Indian crops of corn, beans, squash, and melons. Like the other Indians of the south they also depended partly upon wild foods like mesquite beans, mescal, and the fruits of the cacti. The greater rainfall of the mountain region eliminated the necessity for irrigation.

A considerable part of the area of the narrow flood plains of the upper Gila and San Carlos valleys in the vicinity of San Carlos and Rice is now cultivated by the Indians. The completion of the Coolidge Dam will submerge most of this land along the Gila, and the Indians will have to move to the Fort Apache reservation or will be given the privilege of taking up allotments on the land along the lower Gila, which is to be watered by the project.

In addition to farm crops the Indians now have beef cattle, pigs, and chickens. With few exceptions they adhere to their primitive huts, wikiups, built by bending over poles, binding them at the top, interlacing with branches, and covering the whole with brush or grass. Canvas has now become the chief covering material.

[15] J. H. McClintock: Arizona (3 vols., Chicago, 1916), Vol. 1, p. 29.

After being confined to the reservations the Apaches were rationed by the government until 1902. They are now better situated than any other Arizona Indians with regard to wage-earning employment and make good use of the opportunity. They are also the best laborers and command the highest wages. Important Apache villages are located close to the important mining centers near the reservations as at Globe and Superior. The largest of all is now temporarily located near the Coolidge Dam site, the construction employing a large number of them. Until the recent completion of the Horse Mesa Dam on the Salt River, a similar village was located near by.

The primitive simple Indian, as described above, is slowly but surely vanishing from the scenes. The smaller groups are already disappearing or being submerged in neighboring populations. As development of the agricultural and mineral resources on or adjacent to the reservations proceeds, many of the Indians will doubtless be induced to sell their lands, and will scatter and intermarry among others. To the nation at large all this will be applauded as progress, but to the geographer there must be regret over the obliteration of so much that is unique.[16]

[16] Compare A. L. Kroeber: Native Culture of the Southwest, *Univ. of California Publs. in Amer. Archaeol. and Ethnol.*, Vol. 23, 1928, pp. 375–398.

# THE NEW TERRITORIAL DIVISIONS OF CHILE WITH SPECIAL REFERENCE TO CHILOÉ

William E. Rudolph

WHEN President Ibañez made over the map of Chile a year ago, he drew from out of its obscurity the island province of Chiloé by linking it to the adjacent progressive section of the mainland.

The last part of the country to attain its independence, Chiloé was the southernmost of the eight original provinces into which Chile was divided one hundred and two years ago. In the beginning it included not only the island of Chiloé and adjacent archipelagoes but also portions of the continent. Later on, when colonization of this mainland had begun, Chiloé relinquished all save its islands to the newly created province of Llanquihue. The island province did not progress with other subdivisions of the nation—while the latter were developing their natural resources Chiloé was stagnant. Now and again appeal was made for government aid to develop its fisheries. But more powerful political groups had other uses for the government funds than that of establishing a new industry within a decadent province. Now all is changed. Chiloé regains its lost portions of the mainland. Its capital is removed to Puerto Montt, the southern terminal of Chile's 1900 miles of continuous Longitudinal Railroad. The senators and deputies sent from this province to the National Congress will no longer be slighted, for they represent a population which is contributing materially to the income of the nation. Chiloé is no more on the outside.

## Revision of Territorial Subdivisions in 1927

Before proceeding with our description of Chiloé, it would seem apropos to touch upon this recent revision of territorial subdivisions. It was on the thirtieth day of December, 1927, that President Carlos Ibañez's decree was published in the press throughout Chile, announcing that the nation would be divided into 16 provinces and 2 territories instead of into 23 provinces and 1 territory as formerly. Sixty-five *departmentos* were named as subdivisions of the provinces in place of the 82 which had existed previously.

The proposed changes were cordially received throughout the nation. They went into effect on February 1, 1928. From Table I it is seen that all of the eight original Chilean provinces have been

TABLE I—RELATION BETWEEN OLD AND NEW SUBDIVISIONS OF CHILE

| PROVINCES CONTINUED UNDER NEW SUBDIVISION | DATE OF BECOMING A PROVINCE | OLD CAPITAL | NEW CAPITAL | NEW ORGANIZATION INTO DEPARTMENTOS | FORMER ALLOCATION OF TERRITORY OF DEPARTMENTOS |
|---|---|---|---|---|---|
| Tacna | Following War of the Pacific—still in dispute with Peru | Tacna | Tacna | Tacna<br>Arica | No changes |
| Tarapacá | 1884 (acquired from Peru) | Iquique | Iquique | Pisagua<br>Iquique | No changes |
| Antofagasta | 1888 (acquired from Bolivia with certain Chilean territory added) | Antofagasta | Antofagasta | Tocopilla<br>Loa<br>Antofagasta<br>Taltal | No changes |
| Atacama | 1843 | Copiapó | Copiapó | Chañaral<br>Copiapó<br>Huasco | *<br>*<br>* |
| Coquimbo | Original 1826 | Serena | Serena | Serena<br>Elqui<br>Ovalle<br>Illapel | *<br>*<br>*<br>*Includes small transfer from Aconcagua |
| Aconcagua | Original 1826 | San Felipe | Valparaiso | Petorca<br>San Felipe<br>Andes<br>Quillota<br>Valparaiso | *<br>*<br>*<br>Transferred mostly from Valparaiso; balance*<br>Transferred mostly from Valparaiso; a small portion from Santiago; balance* |
| Santiago | Original 1826 | Santiago | Santiago | Santiago<br>Melipilla<br>Maipo | *Small transfers from O'Higgins and Aconcagua<br>*<br>Transferred from O'Higgins |
| Colchagua | Original 1826 | San Fernando | Rancagua | Rancagua<br>Cachapoal<br>Caupolican<br>San Fernando<br>Santa Cruz | Transferred mostly from O'Higgins; balance*<br>Transferred partly from O'Higgins; balance*<br>*<br>*<br>Transferred partly from Curicó; balance* |
| Talca | 1833 | Talca | Talca | Curicó<br>Mataquito<br>Lontué<br>Talca | Transferred from Curicó<br>Transferred partly from Curicó; balance*<br>*<br>* |
| Maule | Original 1826 | Cauquenes | Linares | Loncomilla<br>Linares<br>Parral<br>Constitución<br>Cauquenes | Transferred from Linares<br>Transferred from Linares<br>Transferred from Linares<br>Transferred partly from Talca; balance*<br>* |
| Nuble | 1848 | Chillán | Chillán | San Carlos<br>Chillán<br>Bulnes<br>Itata<br>Yungay | *<br>*<br>*Includes small transfer from Concepción<br>Transferred from Maule<br>*Includes small portions from Concepción and Bio-Bio |
| Concepción | Original 1826 | Concepción | Concepción | Tomé<br>Concepción<br>Yumbel<br>Coronel<br>Arauco | *<br>*<br>*<br>Transferred partly from Arauco; balance*<br>Transferred from Arauco |
| Bio-Bio | 1876 | Los Angeles | Los Angeles | Laja<br>Mulchén<br>Angol | *<br>*<br>Transferred mostly from Malleco; balance* |
| Cautin | 1887 | Temuco | Temuco | Traiguén<br>Victoria<br>Lautaro<br>Temuco<br>Imperial<br>Villarrica | Transferred from Malleco<br>Transferred mostly from Malleco; balance*<br>*<br>*<br>*<br>Transferred from Valdivia |
| Valdivia | Original 1826 | Valdivia | Valdivia | Valdivia<br>La Union<br>Osorno | *<br>*<br>Transferred from Llanquihue |

*Indicates territory formerly within same province.

FIG. 1—Map showing the changes in the provincial subdivision of Chile. Scale approximately 1:13,000,000.

| | | | | | |
|---|---|---|---|---|---|
| Chiloé | Original 1826 | Ancud | Puerto Montt | Llanquihue<br>Ancud<br>Castro | Transferred from Llanquihue<br>*<br>* |
| Territory of Aysen | | | Puerto Aysen | | Made up from transfers from Llanquihue, Chiloé, and Magallanes |
| Territory of Magallanes | | Magallanes (formerly called Punta Arenas) | Magallanes | Natales<br>Magallanes<br>Tierra del Fuego | *<br>*<br>* |

Provinces discontinued under new subdivision are: Valparaiso (Valparaiso), 1842; O'Higgins (Rancagua), 1883; Curicó (Curicó), 1865; Linares (Linares), 1873; Arauco (Lebu), 1859; Malleco (Angol), 1887; Llanquihue (Puerto Montt), 1861.

retained. Of the twelve provinces created from territory of the original eight during the first century of the nation's history, seven have been discontinued. The three provinces formed from territories ceded by treaties following the War of the Pacific remain unchanged. The commission which studied and made recommendations for the new division stated frankly in its report that new provinces had been created from time to time, not because they were required for administrative purposes, but merely to gratify local sentiment or to further schemes of politicians.[1]

## The New Provincial Boundaries as Compared to the Old

When it is recalled that only short stretches of Chile's 4000 miles of national frontier had been adjusted prior to the beginning of the present century, it can be understood why the defining of provincial boundaries, many of them located within barren deserts and virgin forests, received scant consideration. A large number had been laid out while the nation was still young, and they had become obsolescent. Others had been changed frequently, and latest maps failed to show them correctly.

The outstanding feature of the new subdivision is its simplicity. Each province now extends from the Pacific Ocean to the eastern frontier, excepting Concepción, without international frontier, and Bio-Bio, without coast line. Formerly there were five provinces which had no coast line and five which did not extend to the frontier.

Of the new boundaries many now coincide in general with lines of watershed barriers instead of following watercourses. Valdivia, for instance, no longer has the Rio Toltén at its north and the Rio Bueno at its south—its limits now follow the heights of land farther south in each case. Such a change, by reducing a single province to the waters of a single drainage system, settles for all time questions of ownership where water resources may become important for power or for irrigation. It has also removed the river boundary, which complicates the administration of communities on opposite sides of the river.

Means of communication have also been taken into consideration, the new boundaries linking to a departmental or provincial capital those communities which have most of their business with that capital. This has united communities with similar aims and interests and has tended to eliminate the minorities from these standpoints, which are too often completely neglected as a result of being inadequately represented.

[1] La nueva división territorial de la República [being the report of nine members of the Commission to the Minister of the Interior], *Rev. Chilena de Hist. y Geogr.*, Vol. 57, 1928, pp. 6–38, Santiago de Chile. The governmental decree is based on the commission's report, though it departs from its recommendations in detail.

A single geometric boundary which appeared on the old map, the 47th parallel of latitude between the province of Llanquihue and the territory of Magallanes, has been taken out.

## Results To Be Attained from the New Subdivision

The new subdivision, by decreasing the number of provincial and departmental organizations, should be of material assistance toward attaining a balanced budget for Chile. It should also simplify and speed up the machinery of the government. For example, the coal mines and coal shipping ports now lie entirely within the province of Concepción, whereas formerly they were divided between Concepción and Arauco. Measures are at present under way for increasing the output of these coal mines, a tax upon foreign fuel oil having been instituted to provide funds for subsidizing this industry. It should work out advantageously to have the coal industry thus located within a single province, in view of the controversies that might arise with two provincial organizations complicating the administration of the enterprises.

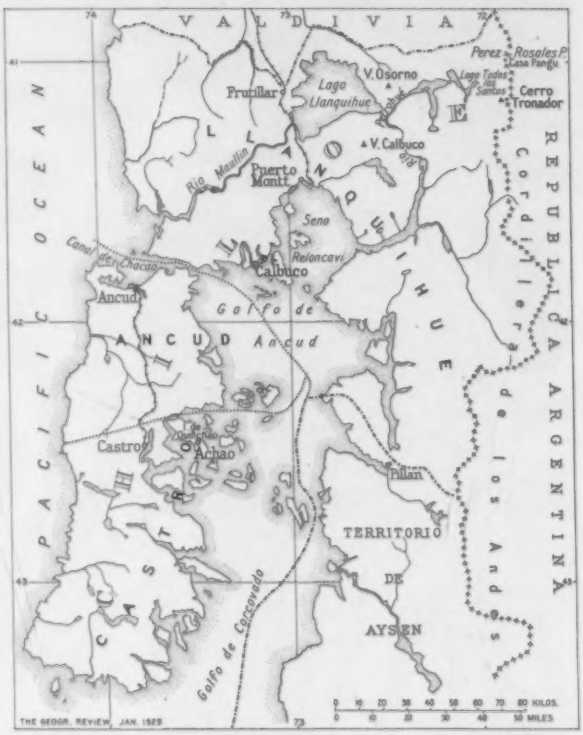
V A L D I V I A
Perez
Rosales P.
Casa Pangue
V. Osorno
Lago Llanquihue
Lago Todos los Santos
Cerro Tronador
Fruitillar
L L A N Q U I H U E
V. Calbuco
Rio Maullin
Puerto Montt
Seno
Reloncavi
Canal de Chacao
Calbuco
Ancud
Golfo de Ancud
A N C U D
Castro
Achao
Pillan
TERRITORIO DE AYSEN
Golfo de Corcovado
P A C I F I C O C E A N
C O S T A
C o r d i l l e r a d e l o s A n d e s
R E P U B L I C A A R G E N T I N A
THE GEOGR. REVIEW, JAN. 1929
0 10 20 30 40 50 60 70 80 KILOS.
0 10 20 30 40 50 MILES

FIG. 2—The new province of Chiloé: The extreme south, comprising islands of the Chonos Archipelago and the Guaitecas Islands, is not shown. Compare Figure 1. Scale approximately 1:3,250,000.

Doubtless the primary aim of the Ibañez government in promulgating the changes was ultimate decentralization of administrative functions to the provinces. Chile, more than 2500 miles long and averaging only 111 miles in width, is hardly adapted to being managed from a central seat of government. Yet in this country the provincial officers have thus far been accorded little authority; all

FIG. 3

FIG. 4

FIG. 5

FIG. 3—Looking up the glacial valley below Tronador leading to Lake Todos los Santos.

FIG. 4—A comparatively recent lava flow from Osorno, upon which new forest growth has sprung up.

FIG. 5—The face of a glacier flowing from Tronador. It is said to be receding at the rate of nearly three feet a year.

public business, even trivial matters affecting a limited region, being transacted at the nation's capital.[2] People of the northern and southern regions of the country consider themselves grossly neglected by the legislators at the capital. Too often their needs are not fully understood there. The official at Santiago is apt to think of the arid northern provinces as regions where rain is unknown and modern housing is quite unnecessary. He is too far away to comprehend the sufferings that follow a single freak rainstorm of the desert, such as the exceptional rains of 1911 which spread devastation in the nitrate fields. Thus, lavish appropriations for ill-advised public works are approved for certain sections, while urgently required improvements are refused to others. There is small wonder that such government has been expensive and inefficient.

Decentralization of legislative and judicial functions from the Chilean national capital to the provincial seats cannot be effected overnight—it must be worked out slowly. The way has been cleared by the proper division of the nation into states which will work as units in harmony with one another.

[2] So unimportant is the province that in Chile one speaks of visiting a certain city or a section near a city, of traveling to the south, the north, the cordillera, or the coast; seldom is the name of the province mentioned. It has not even been customary to include the name of either province or *departmento* in addressing mail.

## The New Province of Chiloé

To return to our discussion of the province of Chiloé. Chile's three dominant physical features—the Coast Range, Central Valley, and Cordillera of the Andes—have been invaded by the sea in the far southern part of the country. Near the forty-second parallel of

Fig. 6

Fig. 7

Fig. 6—Lake Todos los Santos from Peulla.

Fig. 7—At the international frontier along the old trail over Pérez Rosales Pass. Instead of depositing stones according to the custom of the older people of the north, travelers have been leaving daisies.

latitude the Coast Range disappears into the waters of the Canal de Chacao. It reappears as the island of Chiloé and continues in a series of archipelagoes. Only at the narrow boggy isthmus of Ofqui, forming the Peninsula de Taitao, is the Coast Range again joined to the mainland. The Central Valley contains a number of large lakes before disappearing at the Gulf of Reloncavi. Southward it forms an intricate system of canals. The steep western slopes of the Andes fall off abruptly into the sea, causing a curiously denticulated coast where their bulwarks have been invaded at innumerable fiords and estuaries.

The province of Chiloé now comprises the portion of the continent lying between a watershed line approximating the 41st parallel at the north and an irregular line south of the 42nd parallel at the south, the large island of Chiloé (about 3000 square miles), several other large islands, and the archipelago of Chonos as far south as the Canal King at about latitude 44° 40′ S. Within the continental portion of the province are two large lakes, Llanquihue and Todos los Santos, the former having an area of about 300 square miles.

## Glacial and Volcanic Features

The surface features of the province are for the most part the result of glaciation. Lakes Llanquihue and Todos los Santos were originally excavated by ice. Great chains of terminal moraines have been left about their borders. Some of the glacial structures have undergone modification by the forces of vulcanism. These lakes, originally one, were separated by a lava flow from Osorno, which established a higher level for Todos los Santos and caused it to find a new outlet through the Rio Petrohué to the Gulf of Reloncavi (Fig. 2). The narrow tongue of land between the two lakes is composed of volcanic sands, in which large tree trunks are found imbedded.

The fiords and maritime channels appear to have been glacial troughs which extended below sea level, the Canal de Chacao, at latitude 41° 47′, being the northern limit of glaciers which reached the open sea. This view seems to the writer more acceptable than the theory that the archipelagoes are due to depression of the Coast Range until only the highest portions were left above water. The weight of evidence points to elevation rather than depression in later times. Darwin found sediments ascribed to floating ice upon the island of Chiloé. Near Ancud he noted a great bed of shells of modern species, from among which large forest trees were growing at an elevation of 350 feet.[3] Sundt mentions large erratic blocks, evidently transported by floating ice, both north and south of the Canal de Chacao—such as to indicate that these lands had been at least 200 feet below sea level during the glacial period.[4] The lower height of the Andes in this region than in the north must be to some extent due to glaciation and to mechanical disintegration under a wet climate during the last era.

A number of the mountains are volcanic cones which have been active in the recent past. Calbuco, 6611 feet, had periods of eruption in 1893, 1895, and during April, 1917. Since then it has frequently given off "smoke." During eruptions of this volcano it was feared that a lava flow might descend to the Rio Petrohué and dam its course,

[3] Charles Darwin: Journal of Researches, etc., 2nd edit., London, 1860, p. 297.

[4] Lorenzo Sundt: Estado actual de los conocimientos jeolójicos en Chile, *Estadistica Minera de Chile en 1906 i 1907*, Vol. 3, Santiago, 1909, pp. 503–514; reference on p. 510.

FIG. 8

FIG. 9

FIG. 10

FIG. 8—The cone Osorno from the southern shores of Lake Llanquihue.
FIG. 9—The volcano Calbuco, viewed from Lake Llanquihue.
FIG. 10—Cultivated lands upon the moraine bordering Lake Llanquihue, where half a century ago was dense forest.

restoring the older conditions under which Lake Todos los Santos drained toward the west. This would have resulted in heavy damages from inundations, but luckily none of the lava reached the river. The 1917 eruption, according to observers in the region, sent out little in comparison with that of 1893. A large quantity of sulphur appeared as a result of the last disturbance.

Of Osorno, 8727 feet, there is no record of activity more recent than a light eruption during the year 1837. Darwin saw this mountain in eruption from the island of Chiloé on January 15, 1835. Osorno has a crater about 1500 feet in diameter in which snow has accumulated. Vapors have been noted here by climbers of recent years. That volcanic activity in this section of Chile is by no means concluded was shown on October 4, 1927, when the cone Llaima, hardly 200 miles north of Chiloé, threw out cinders for several days.

## A Region of Heavy Rainfall

The province lies in the region of heavy rainfall. During the summer months the fall is somewhat less than in other seasons of the year. Records over a period of 34 years give Puerto Montt an average of 2160 millimeters (85 inches) of rainfall. Ancud, for 23 years, had 2092 millimeters (82 inches).[5] At nine observation stations in the region of this province rain occurred on more than half of the days of the year, for an average, during the years 1911 to 1916. At Guafo, northwest of the Chonos, the average was 259 days. Much of this rain was in the form of showers, however, the number of days recorded as continuously cloudy being considerably less than those during which precipitation occurred. Peulla (620 ft.), at the head of Lake Todos los Santos, had an average of 133 inches from 1918 to 1925, Casapangue (1080 ft.) had 139 inches. Frutillar, the driest station of the region, east of Lake Llanquihue had 66 inches.[6]

Snow is most unusual at seaboard in the region, its northern limit being the 47th parallel. Even at passes in the Andes, reaching three and four thousand feet, there is seldom a considerable amount of snowfall in winter. The perpetual snow line is at about 6000 feet at the 43rd parallel. Glaciers reach the sea only south of the 46th parallel.

The difference in temperature between summer and winter is much less than the latitude would indicate. The range at Puerto Montt was from 15.8° C. (60.4° F.) average in January to 8.1° C. (46.6° F.) in August, with a yearly average of 11.4° C. (52.5° F.), during the period 1911 to 1916.[7] The same records for Ancud give

[5] Mark Jefferson: The Rainfall of Chile, *Amer. Geogr. Soc. Research Ser. No. 7*, New York, 1921, p. 27; tabulation from data of the Inst. Meteorol. y Geofísico de Chile, Sección Lluvias.

[6] Lluvias mensuales, 1918–1925, *Servicio de Meteorologia Agricola, Publ. No. 37*, Santiago, 1926.

[7] Tables quoted by Walter Knoche in chapter on "Breve estudio del clima de Llanquihue y Chiloe," in Turismo en la Provincia de Llanquihue (by German Wiederhold), Santiago, 1921, p. 43.

15.3° C. (59.5° F.) January, 8.4° C. (47.1° F.) August, 11.3° C. (52.3° F.) yearly average. At the island Melinka, 43° 54′, it ranged from 13.4° C. (56.1° F.) in January to 7.4° C. (45.3° F.) in August, with an average of 9.9° C. (49.8° F.). Such equable climate is due to the high degree of cloudiness. When the sun does shine in southern Chile, upon its snow-capped ranges and glaciers and beautiful woods, there is a rare treat for the traveler—and such days are more prevalent

FIG. 11—In the farming region of northern Llanquihue.

than the bad ones during three months of the year. Perhaps I appeared too enthusiastic over a period of fine weather at Ancud, for the proprietress of the hotel interrupted: "But, Señor, what of the other nine months, with weeks upon weeks of rain, when we can only stay close to the fire to keep comfortable? What of the winter when we scarcely put foot into the street?" We needed no confirmation of her words. The odor of damp mold from the woodwork of all the houses we entered told its own story.

## THE FORESTS

Well-nigh impenetrable forests are the result of the heavy precipitation. The soil is so wet that roads are of little avail. In earlier times persons have lost their lives in the mud. Two men who traveled the length of Chiloé on horseback in recent years were accustomed to rescuing each other with a lariat. Corduroy roads are being built in the north of the province, however; and, while these do not remain in good condition for long, they have materially lessened the difficulties and dangers of travel. Certainly there has been improvement since the colonization days of 1856, when a newspaper stated that cattle stealing was unknown in the region inasmuch as no thief could escape with such booty through the damp forests.

The trees of these forests are in great part without value. Most common is the *coihue* (*Nothofagus dombeyi*), a very beautiful tree but a species all too abundant. "Too heavy and weak for lumber, too wet to burn, [these trees] simply keep out the sun and make a quagmire of the ground."[8] The *alerce* (*Fitzroya patagonica*) is a most useful wood, although scarce. It is one of the gigantic conifers of America, there being specimens 200 feet in height and 16 feet in diameter. Trees 4000 years old have been reported: trees over 2000 years old appear to be well authenticated. *Alerce* is used in large quantities for shingles. Other useful trees are the *lingue* (*Persea lingue*), used for furniture and floors, and the roble (*Nothofagus obliqua*) a dense timber of dark-red color, used for railroad ties and posts. The bark of the *lingue* is used for tanning.

Much of the smaller growth resembles that of tropical forests. Trailing parasites, ferns, cane, and dense underbrush abound. Tree ferns are found upon the island of Chiloé. Blackberry thickets cover the burned and cut-over lands that have not been cultivated. Much like the tropical forests from the standpoints of darkness, dampness, and impenetrability, the Chiloé forests differ from these in that they have few snakes or dangerous insects. A large hairy spider, noticed perhaps where a ray of sunshine pierces the darkness of the trail, is the only poisonous creature.

## Industries

In the Lake Llanquihue region agriculture and stock raising have come to rank with forestry as important industries. The soil is fertile, consisting largely of decomposed volcanic products, and the country is rolling. Clearing the land has been the difficult problem, for it is hard to keep fires burning in so wet a climate. Probably there are few places in temperate regions where, as in southern Chile, the forest fire is an aid instead of a menace. Advantage is taken of each spell of dry weather to start fires, which appear to require but little control. Smoke is seen in all directions in the settled portions during the summer months. Thanks to the patience and persistence of the settlers, large areas have been converted to farm land and pastures. The potato is found growing wild on the island of Chiloé, and it is generally considered that it originated in this region.

But by far the most important resource of Chiloé is its fishing, an industry still in its infancy in Chile. The waters about the province are rich in fish. At times of the year, after high tide, the natives scoop fish up in barrels from walled enclosures. Yet, whereas many settlements of the islands depend upon the sea for their living, only a very small portion of the available supply is utilized. Each winter

[8] Mark Jefferson: Recent Colonization in Chile, *Amer. Geogr. Soc. Research Ser. No. 6*, New York, 1921, p. 13.

FIG. 12

FIG. 13

FIG. 14

FIG. 12—Looking eastward over Puerto Montt, capital of the new province of Chiloé.
FIG. 13—Looking westward over Puerto Montt.
FIG. 14—So great is the range of tide at Puerto Montt that boats may be loaded and unloaded at low tide by oxcarts.

thousands of tons of sardines and anchovies are washed ashore by the waves, to be preyed upon by sea birds. Mackerel are also plentiful. Of shellfish there are quantities of oysters and *choros*, the latter being the Chilean mussel. A whaling company has been operating at San Pedro Island, southeast of Chiloé, for some years.

Canning has been done on a small scale at Calbuco and a few other places, but such establishments are all too inadequate. Mean-

FIG. 15—Calbuco.

while one finds canned fish from Europe and North America upon the shelves of nearly every grocery store in the republic. Such has been the condition for years, while the island province was vainly petitioning the government for funds to install a modern fishing fleet and build canning and curing plants.

## SETTLEMENTS AND TRADE ROUTES

Although colonization under the Spaniards began in the sixteenth century, it is only within the last 75 years that important communities have been built up.[9] The population of the *departmento* of Llanquihue, Llanquihue Province, increased from less than 7000 in 1865 to over 43,000 in 1920. Puerto Montt, the new capital of Chiloé, was founded by Vincente Pérez Rosales in 1853, its first population consisting of sixty German families. The early name, Melipulli, was changed in order to honor President Montt, during whose administration the city was settled. Its bay is well protected by islands, forming one of the safest harbors in Chile. The city had 10,200 population in the census of 1920.

Of the smaller settlements, none number over 5000. Calbuco is a port upon an island founded by families fleeing from the Indian

[9] *Ibid.*, p. 23.

attack which destroyed the city of Osorno in 1604. Fishing and lumbering are its industries.

The island of Chiloé shows a much slower rate of increase: for the entire island from 59,000 in 1865 to 110,000 in 1920. The attempt at foreign colonization made toward the end of the century met with little success.[10] On the other hand emigration has been a problem. This is in part periodic, a large number of Chilotes going to the main-

FIG. 16—Ancud, from the mole.

land in the spring for work in the agricultural settlements of Llanquihue and returning in the winter. Pierre Denis cites the case of the archipelago of Quinchao, east of Chiloé, in which, thanks largely to temporary emigration, a population of 50 to the square kilometer is supported.[11]

Ancud, former capital of Chiloé, was known as San Carlos (de Ancud) when visited by Darwin in 1834. The port ships potatoes, woods, and sea food. The city had 4295 inhabitants in 1920, of whom, according to Martin,[12] 242 were German. There was only one motor car in town when I visited there in 1926. On June 7, 1927, Ancud was crossed by a hurricane which destroyed the poor section and caused other damages.

Castro, the earliest capital of Chiloé, was described by Darwin as "forlorn and deserted" in 1834: it now has some 2700 inhabitants. The town is at the southern end of the new railroad serving the northern portion of Chiloé island. It has a good harbor and bids fair to attain some importance as the fisheries are developed. Achao is another small port situated upon the island of Quinchao.

[10] See Mark Jefferson, Recent Colonization; also Jorge Schwarzenberg and Arturo Mutizábal: Monografía geográfica e histórica del archipiélago de Chiloé, Concepción, Chile, 1926.

[11] Pierre Denis: Amérique du Sud, Part II, Paris, 1928, p. 363.

[12] Carl Martin: Landeskunde von Chile, 2nd edit., Hamburg, 1923; reference on p. 738.

It is safe to say that prior to colonization of the last 75 years, travel in the province was mostly confined to waterways of the sea. Two railroads have since been built, one connecting Puerto Montt with Santiago as the southernmost link of the Longitudinal Railroad of Chile, and the other between the ports of Ancud and Castro. Both are operated by the Chilean government. Wood is the fuel used.

The railroad on the island of Chiloé is of two-foot gauge. The fastest train on its schedule covers its 53 miles in slightly less than five hours. Still this line has been an important factor in developing the interior of the island, its principal cargo being potatoes, woods, and hogs.

The line to Puerto Montt, of five-and-a-half-foot gauge, was completed in 1913. Lumber, cattle, and farm products comprise its principal freight. This line has also made accessible to dwellers of the central cities the scenic district of Lake Llanquihue, a large summer colony having been built up at Puerto Varas. Passenger traffic on this line has been increased in recent years by travelers from other countries, attracted to southern Chile by the natural beauties which have earned it the name "the Switzerland of America." A prominent North American syndicate recently made arrangements with the Chilean government for building hotels in the Lake Llanquihue district to provide for the travelers who visit here in increasing numbers each summer.

Subsidiary to the railroads is the commerce upon the lakes. That upon Llanquihue has assumed important proportions. Another navigable waterway is the Maullin River. This river, which drains Lake Llanquihue, may be ascended for 26 miles by vessels drawing up to nine feet, and several miles farther by smaller boats. It serves as an outlet for timber in large quantity.

Roads have been built to connect points between which there is no water route. Most of these are for oxcarts, although a few have been adapted to motor car traffic.

In recent years a new transandine route has been developed to connect the Chilean and Argentine railway systems. On leaving the Longitudinal Railroad at Puerto Varas, travel is by small boats and motor cars to Casa Pangue, thence by horses and mule-pack train across the frontier to the Argentine lakes. Boats and motor car lines in Argentina connect with Neuquen, from which point the rails are continuous to Buenos Aires. This route took on importance during the winter of 1926, when the Transandine Railway was blocked for some months by snow. Travel was possible by the Lake Llanquihue-to-Argentina route; for, whereas this crosses the Andes eight full degrees of latitude south of the railroad, the Pérez Rosales Pass (3445 feet) is low enough to escape heavy snows. Furthermore, neither the Chilean nor the Argentine lakes freeze during the winter

months. The fact that this is an all-year-round route should make it desirable for travel. It may possibly develop some economic importance, although there are more advantageous crossings of the Andes farther north.

## A Region for Exploration

There is no better way to conclude these notes than to mention the great lack of knowledge of the province of Chiloé. Much of its territory is within one of the portions of the earth's surface of which comparatively little study has been made, although it is a region worthy of further exploration both from the standpoint of industrial economics and of science. That no mines have been exploited in the province thus far seems odd, for its rock formations are quite similar to those in which Chile's vast copper deposits and other ores have been discovered. Auriferous beach sands found along the shores of Chiloé Island would indicate that there are perhaps placer deposits of gold in the region which have survived glaciation. For years inhabitants of this island have known of the existence of platinum in beach sands in the far southern section of its western coast—white gold they called it, without realizing its value.[13] An English company was recently organized to investigate and to exploit the platinum resources believed to exist.

Although it is nearly a century since Darwin visited and wrote about Chiloé, comparatively little has since been added to our knowledge of this interesting region.

[13] Fritz Mella: El Platino en las arenas negras de Chiloé, *Riqueza Minera de Chile*, Santiago, November, 1927, p. 199.

# LITTLE DIOMEDE ISLAND, BERING STRAIT*

D. Jenness

*National Museum of Canada*

THE two Diomede Islands, Little and Big, situated in the middle of Bering Strait, have been for countless ages the stepping-stones from Siberia to Alaska, from Asia to America. The easternmost point of Asia, East Cape, is but twenty-one miles from Big Diomede Island; the westernmost point of America, Cape Prince of Wales, twenty-two miles from Little Diomede; and the distance between the two islands is a scant four miles. On a clear day, Asia and America lie within mutual view, and the Eskimos cross from one continent to the other in their small skin boats, quite unconscious that they are bridging the gap between the world of the Orient and the world of the Occident. As they cross today, so their ancestors crossed a thousand years ago and a thousand years before that; for, without a doubt, Bering Strait has been one of man's principal routes from Asia to America since the close of the glacial epoch.

The United States Revenue Cutter *Bear* landed me on Little Diomede Island on July 26, 1926, and a small launch from the mainland picked me up on August 20. During the interval I excavated some old house sites and rubbish heaps in an attempt to unravel the history of its habitation. The temperature was very low for midsummer, the maximum reading of the thermometer being 45° F. (70° in the sun); and the island was frequently swept by driving banks of fog. With my Eskimo workmen I spent two days on Big Diomede Island also but was precluded from further visits by strong gales from the south. August and September are stormy months in Bering Strait; and, though ships can find shelter between the islands on either the north or the south side according to the direction of the wind, the rocky shores often make landing impossible. Navigation opens in June and closes early in October; but communication with the mainland is very uncertain. Besides the Revenue Cutter *Bear* and the Bureau of Education's schooner *Boxer*, each calling once or sometimes twice during the summer, there are only one or two small trading boats that drop in during a slack period to barter for walrus ivory. You may easily arrange to be landed on Little Diomede Island in July or even in June; but whether you will be fortunate enough to escape from it again before winter, is sometimes doubtful.

Little Diomede, which is nearly two miles long by over a mile

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wide with its axis running roughly north and south, rises steeply from the water's edge to a plateau 1300 feet above sea level. Formerly it was a huge crag of granitic rock containing tabular masses of recrystallized limestone; but the limestone weathered, and the crag broke down into a mass of breccia, leaving steep precipices at various places along the shores. There is only one landing place, a narrow beach of waterworn boulders three hundred yards long on the southwest side of the island, where the mountain dips a little more gently towards the sea; and even this is covered by breakers in stormy weather. The native village lies on the slope above, a motley collection of stone huts with frame porches strewn on either side of a narrow pathway, wherever the ground is sufficiently level to furnish a foundation. Above the village, among the breccia of the hillside, is the graveyard. Tradition states that in ancient times the graveyard was on the site of the present village and that the old village lies beneath the water; a native fishing off the point, it is said, once drew up a roof beam on the end of his line. Certainly the water is shallow halfway from the village to Big Diomede, and the coast line seems new, the cliffs showing no marked signs of erosion. Yet, if a subsidence has occurred, it must have been purely local or else long before any memory of its occurrence. At Wales, 22 miles away on the mainland of Alaska opposite, there is definite evidence that the coast has been stable for several centuries and probably very much longer. At that place a small stream rushes down a ravine in the mountains, turns almost directly back on its course when it reaches the tundra, and slowly meanders for a mile before it bisects the modern village on the shore and enters the sea over a shallow bar. About 100 yards back from the beach (200 yards following the meanderings of the stream) it skirts a low mound containing the ruins of ancient houses, inhabited, the natives say, when the stream could be navigated to their doors. The floors are three feet below the surface, and both their depth and their contents indicate an antiquity of at least four or five hundred years. Evidently the coast has remained stable since their occupation, but the shore line has slowly extended outward. Since the entire plain is uniformly but a few inches above sea level and is underlain by beach sand back to the talus slope, it must have arisen from similar deposition, and the coast must have continued stable

FIG. 1—Map showing the position of the Diomede Islands. Scale 1:9,000,000.

throughout the whole period of its formation—a period doubtless covering several thousand years. If there is any truth at all in the native tradition about the sunken village off Little Diomede Island, the explanation may lie with the ocean current, which sweeps between the two islands, generally northward, at a rate of from two to five

FIG. 2—Little and Big Diomede Islands, from the east.

miles an hour, so that in the lapse of centuries a low promontory may conceivably have been scoured away by the combined action of ice and water.

## VEGETATION AND ANIMAL LIFE

Mr. A. E. Porsild and his brother, botanists attached to the North West Territories and Yukon branch of the Canadian government, joined me during my last week on the island and made a thorough survey of its land flora, in the hope that it might throw some light on the problem of a possible land bridge between Asia and America since Pliocene times. Mr. Porsild collected eighty-six species of flowering plants and mosses and more than a hundred of lichens, which he proposes to identify and study in the near future. In the meantime he has kindly furnished me with the following brief note:

> The flora of Little Diomede, even though it exceeds the land fauna in the number of species present, yet shows remarkable deficiencies when compared with the flora of the mainland on either side of the strait or with that of the large St. Lawrence Island to the south. This is due, of course, to its distance from the mainland, the unfavorable climate, and the scarcity of soil. On the precipitous slope to the south and west, where millions of birds nesting through the centuries have filled the spaces between the rocks with manure, the ground is covered in some spots with a luxuriant growth of grasses and cotton sedges. Here abounds also the "Eskimo potato," a Claytonia, probably endemic, with a white, rather inconspicuous flower and a root, greatly relished by the Eskimos, that attains in fertile soil the size of a large walnut. The pretty pink Claytonia and the blue monkshood form extensive patches in sheltered places.
>
> The frequent fogs and rains and the abundant supply of manure promote the growth of many lichens that cover the rocks in thick crusts. On the slope the brilliant Xanthoria and Cetrarias help to brighten the gray rocks; but the black Alectoriae that predominate over the plateau on the summit of the island make the landscape seem bleaker than if all vegetation were lacking.

A few foxes and white bears visit the Diomedes during the winter, and once within the memory of the natives a lemming was caught on

Little Diomede. Apart from these there are no land animals, not even mice. Marine life abounds. Killer whales (*Orca gladiator*) are not uncommon, and walrus and bowhead whales (*Balaena mysticetus*) pass by in large numbers both in spring and fall. Many beluga (*Delphinapterus catodon*) migrate northward between the two islands

FIG. 3—Big Diomede Island, from Little Diomede Island.

when the ice breaks up, but most of them pass to one side or the other at the close of the brief summer. Of seals there are four species—the hair (*Phoca hispida*), bearded (*Erignathus barbatus*), harbor (*Phoca richardii pribilofensis*), and ribbon (*Phoca fasciata*). The ribbon seal is scarce, the harbor seal becomes plentiful only in August and September, but hair and bearded seals frequent the islands throughout the year. The natives catch many sculpins and crabs and a few polar cod, but they give little attention to fishing.

Land birds too are few. A snowy owl was seen; in place of mice it preys upon the eggs and young of sea birds. And there were the ubiquitous snow buntings. A wader occasionally lingers along the beaches. The natives shoot a few eiders or catch them occasionally with the bolas; but neither eiders nor old squaw ducks are plentiful. Several black-throated loons flew by, or settled on the water, during my stay; the yellow-billed loon rarely visits. Yet the islands are not deserted. Every cliff is a nesting ground for murres, cormorants, kittiwakes, puffins (two species), and another bird I could not identify; and auklets, flying in clouds like mosquitoes, darken the sky.

## LITTLE DIOMEDE VILLAGE

With the exception of a Norwegian missionary and his wife the only inhabitants of Little Diomede were Eskimos. Many of them wander to Nome and elsewhere during the summer, but they nearly always return before winter. A census at Christmas, 1925, placed their number at 94; when Kobelev landed on the island, in 1779, it was 160.[1] As in many other places, the Eskimo strain here is not pure; one or two natives show traces of white admixture, and several almost

[1] P. S. Pallas, in *Neue Nordische Beyträge*, Vol. 4, 1783, p. 107, St. Petersburg and Leipzig. The population of Big Diomede Island at the same date was 398; now it is reduced to six or seven families. The Russians first sighted the Diomede Islands in 1730 but did not visit them until 1732 (F. A. Golder: Bering's Voyages, Vol. 1, *Amer. Geogr. Soc. Research Ser. No. 1*, 1922, pp. 21–24).

certainly have Chukchi blood in their veins. Yet the dialect is so typically Eskimo that a native from Greenland could converse with the Diomede Islanders with little difficulty after a few days' contact.

The village itself is of an unusual type, even in Alaska. The houses, ten in number, are built of beach-worn stones laid one above another with only earth for mortar. Inside they are sheathed with rudely dressed planks, but that is apparently a modern innovation; in former days only the floor and gabled roof were of planks, and on the roof these were often replaced by whale ribs. Most of the houses now have frame porches, sometimes quaintly two-storied, on the same ground level; but two still preserve a long dark passageway of stone on a lower level, with whale ribs framing the entrances. The visitor stumbles with bowed head along the ill-laid boulders, steadying himself with one hand against the greasy walls; and, after groping thus for about ten yards, suddenly straightens up and pushes his head and shoulders through a round hole in the middle of the floor. The room is square, with wide shelves the length of the walls along three sides and a skylight of walrus intestine. The family or families, for there are two in each of these houses, sit around on the floor, the men perhaps carving ivory, the women sewing or boiling a pot of meat over the seal-oil lamp; for, owing to the scarcity of wood, blubber remains the principal fuel. Two or three children probably sit on a shelf, dangling their legs over its edge.

The interesting feature about these houses is that nowhere on the American continent, outside of Greenland, do any Eskimos live in houses quite similar. Yet there are ruined dwellings of much the same type throughout the Arctic Archipelago, around the shores of Hudson Bay, in Baffin Island, and even in Labrador. In all these regions, as on the Diomede Islands, driftwood was too scarce to permit of the substantial wooden houses that were erected by the Eskimos of the mainland from the Kuskokwim to beyond the Mackenzie River delta; the natives therefore had recourse to stone. But in the central Arctic, from Coronation Gulf to Labrador, snow huts, apparently a local invention, superseded huts of stone several centuries ago, and the latter survive in use only on the fringes of the Eskimo area—in northern Greenland on the one side and on the Diomede and King Islands of Bering Strait on the other.

## Archeological Relations

The parallel in the dwellings becomes still more significant when we consider the remains that have been found in the old stone houses of northeastern Canada and compare them with the remains unearthed in Alaska. One naturally expects to find some differences throughout so wide an area, with resources varying from one region to another;

FIG. 4

FIG. 5

FIG. 6

FIG. 4—The landing place and village on Little Diomede Island. Note the breccia on the mountain slope.

FIG. 5—Stone houses with two-story frame porches on the ground level, and stone passages below.

FIG. 6—Wales, the nearest point of America to Asia. In the background, on the right, lies the mound where the ancient inhabitants built their houses.

yet, broadly speaking, the remains from the two regions are so remarkably homogeneous that they plainly represent a single culture. This culture, called Thule by the Danish archeologist Mathiassen, extended several centuries ago from one side of Arctic America to the other. In Alaska—at least from Bering Strait northward, for the archeology south of this region is but little known—it has changed very little and by slow stages only; but in northeastern Canada it seems to have been suddenly superseded by a culture considerably different and in many respects more primitive.[2]

The slightness of the change in Alaska was less easily observed on Little Diomede Island than at Wales, owing to the greater difficulties of excavation. The space available for habitation being limited, the natives had erected and re-erected their dwellings on the same sites, and most of the ancient houses were concealed beneath the modern. Others were buried beneath huge boulders that had rolled down the mountain side. The few sites that lay exposed, principally rubbish heaps in front of the dwellings, the Eskimos themselves had overturned to a depth of two or two and a half feet in order to recover the fragments of fossil walrus ivory, which they fashioned into beads and paper knives or sold to traders at $2.50 a pound. The ground was frozen four inches below the surface and, when stripped to frost level, thawed out at a rate of less than two inches a day. Altogether the conditions for archeological work were much less favorable than they had been on the mainland a month earlier, so that only five sites (two imperfectly) were excavated on Little Diomede Island as compared with twelve at Wales. The remains from the two places, however, supplemented each other, and, taken together, throw an interesting light on the earlier history of this portion of Bering Strait.

In some of the more recent ruins at Wales the floor level lay at a depth of from 12 to 18 inches below the general surface of the ground; and two glass beads, with a few fragments of iron, showed that there had been indirect contact with European civilization. Since the Russians reached Anadyr, in northeastern Siberia, in 1649 and soon afterwards explored other parts of the Chukchi Peninsula, introducing iron and beads among the inhabitants, these houses at Wales, which has always been in close contact with the settlements across the straits, can hardly date later than 1700. On a mound in the tundra behind them was another group of ruins which contained neither iron nor beads and which had floors three feet below the surface; but, although these dwellings must have preceded the others by several centuries, the specimens from the two groups of ruins were for the most part indistinguishable. The older ruins had sealing

[2] See Therkel Mathiassen: The Archeology of the Central Eskimos, *Geogr. Rev.*, Vol. 15, 1925, pp. 544–549; also in Report of the Fifth Thule Expedition, 1921–24, Vol. 4, Copenhagen, 1927.

harpoon heads with open sockets only; the later contained both open-socketed heads and heads with closed sockets like those in use today. The newer ruins, too, contained pipes and fish nets, both of which were absent in the older houses. Apart from these few details, however, there was no indication that the culture of the Eskimos had undergone any material change from the remote period represented by the mound dwellings down to European times. In post-European houses and graves there were stone lamps and grappling hooks for retrieving seals shot at the edge of the ice during the winter and early spring; but the stone lamps were brought from northern Alaska only after 1800, for the older remains contain lamps of pottery alone. The grappling hooks are still more recent, having been introduced within the last fifty years by the Chukchi and Siberian Eskimos who cross the strait each summer to trade on the Alaskan side. It was interesting to find labrets, and also implements for making seal nets and snowshoes, in the mound dwellings at Wales, for these also have sometimes been considered of modern origin. Seal nets, indeed, were known to ancient Eskimo tribes in Greenland, but snowshoes and labrets never extended beyond the Mackenzie River delta.

Before the occupation of Alaska by Europeans, both the Diomede Islands and Wales were far more closely connected with Asia than with America. Flint and serpentine, so common in ruins at Point Hope and Barrow, were comparatively scarce, especially on the Diomede Islands, indicating infrequent contact with Eskimos to the northward. It was from Asia that the inhabitants of the straits acquired the iron, beads, pipes, and fish nets that appear first in the ruins of two centuries ago. Local legends still tell of frequent battles with natives from the Asiatic shore, even of a flight of Eskimos from Wales to Barrow. On the east face of Big Diomede Island are two stone houses a hundred feet above the sea, erected two or more centuries ago at this inconvenient level for no other reason, apparently, than to escape raiders from across the water; and on the mountain slope east of Wales many huge stones were set up on edge to shield the warriors from the arrows of their enemies. The ruined dwellings at Wales and on the Diomede Islands tell the same story; for nearly every house, however deeply buried beneath the soil, contained breastplates of ivory or antler that were worn in rows as armor against attack.

Different from any of the specimens excavated at Wales, even in its mound dwellings, were a few objects recovered on Little Diomede Island. Unfortunately, only one, a harpoon point, was found *in situ*, that is to say, in what seemed to be undisturbed soil 8 feet below the surface. A second specimen, the broken foreshaft of a harpoon, lay almost on top of an overturned rubbish heap beside the schoolhouse. The remainder were purchased from the Eskimos, who had

discovered them when digging for fossil ivory or excavating caches to store their meat. All these objects were inscribed with fine scroll-work altogether unlike the usual Eskimo carving or indeed any carving known in America; and the harpoon point differed in type from those at Wales, although others like it have been collected, without information, at three or four places along the Alaskan and Siberian shores.[3] There can be little doubt that these specimens belong to a separate culture in this region, a culture, to judge from the depth of the harpoon point below the surface and the absence of similar remains in the mound dwellings and later ruins at Wales, of greater antiquity than the widespread Thule culture. The elucidation of its details, however, and the determination of its origin, age, and relation to the Thule culture all await further archeological researches, not, perhaps, on the Diomede Islands, where the difficulties of excavation are considerable, but along the mainland shores on both sides of the Bering Sea and on the large St. Lawrence Island within its basin.

[3] For illustrations of three of these specimens see "Problems of Polar Research," *Amer. Geogr. Soc. Special Publ. No. 7*, 1928, p. 171.

# DAILY MAPS OF WORLD WEATHER

## AN ATTEMPT AT THREE-DIMENSIONAL GEOGRAPHY

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FOR half a century forecasts of weather have been based upon synoptic maps, that is, maps on which are charted simultaneous observations made over the area under jurisdiction of any one nation. Since the area charted should be as large as possible, international coöperation is needed. This is the object of the Commission for Synoptic Weather Information first organized in 1909.[1] At a meeting in London, May, 1928, the Commission considered methods for obtaining, transmitting, and charting definitive data. Action was taken regarding the adoption of a universal code and the making of observations on all oceans at standard times. It was voted that hereafter pressure readings should be expressed if possible in modern units of force, that is, in millibars. The use of an international temperature scale remains for a later conference. Land reports, of course, are easily obtainable from national services. Radio permits us to get data from over the ocean. It is proposed, among other things, that the main collecting and distributing center for the North Atlantic be at the Azores. But the resulting map must be something far different from present surface, or two dimensional, maps. The atmosphere has three dimensions; and the geography of the air—or, as we may well call it, airgraphics—requires the delineation of conditions at various levels as well as at the surface. We are entering an era of utilization of the air for transportation and communication, and a fine field for exploration and survey it offers.

### Pressure Distribution and Forecasting

On our present synoptic maps areas of high and low pressure are marked by logotypes; and the storm track is determined by joining up from day to day the positions of lowest pressure. This assumes that minimum pressure is the true center of air movement, which may not be the case. Hence we have some erratic tracks. When the data are entered and pressure areas defined, the forecaster bases his judgment upon a well known general law, viz: "That a well defined

[1] The history of this Commission is briefly stated in the "Report of the Sixth Meeting, Zürich, September 9–16, 1926," *Meteorol. Office Publ. No. 293*, London, 1927. See also abstracts of reports of subsequent meetings given in the *Meteorol. Mag.*, August, 1928; and in the *Monthly Weather Rev.*, July, 1928.

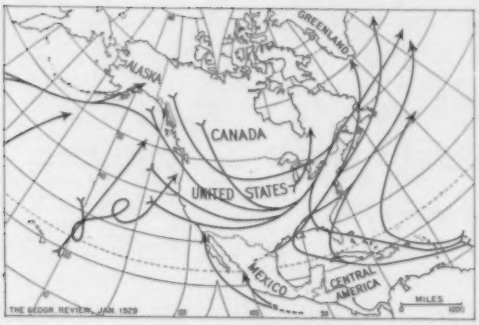


FIG. 1—Storm tracks over North America and adjacent waters. (The projection is Cahill's: scale 1 inch = 1000 statute miles: equal area: errorless parallels: central meridian in each octant rectified.)

cyclonic depression in temperate latitudes will drift to the east at a rate varying with the time of the year, the intensity of gyration, and the intensity and area of the anticyclone immediately in advance." Other causes not preventing, the rotating mass of air will be deflected to the right in the northern hemisphere, owing to the earth's rotation; but, because of the mean gradient of pressure, it will have a northward trend. Forecasting is based mainly upon this expectation of an eastward and somewhat northeast "travel" of the depression. Anticyclones, or regions of high pressure, tend to drift to the southeast.

For many years attention was centered on the "low"; but it is now well recognized that the anticyclone plays the major rôle and determines the onward march if not indeed the development of the low. Some general paths of storms, airways in the best sense of the word, are shown for the United States and bordering waters in Figure 1, covering nearly half of the northern hemisphere; a decided improvement on existing maps, for as matters now stand, owing to the distribution of duties incident to two different governmental bureaus, the Pilot Charts of the Hydrographic Office limit their storm tracks to the oceans, leaving to the Weather Bureau the paths on land. There is thus a break in the record, which necessitates the use of a new base map. A circumpolar map, not for general distribution, enables the forecaster to trace the life history of depressions that enter from the Pacific or from the Atlantic and either cross the continent or sheer off. A map of the northern hemisphere of this type can be found as frontispiece to Part IV of Sir Napier Shaw's "Manual of Meteorology," reproduced in

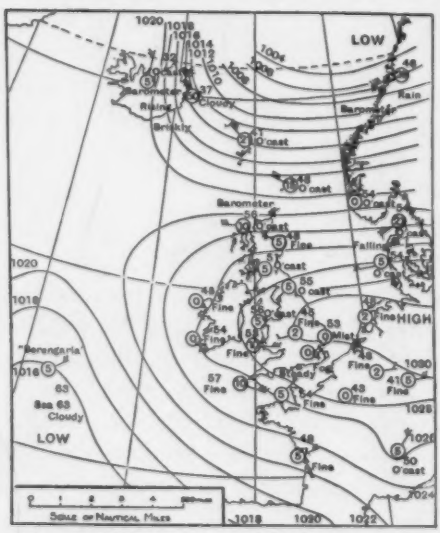


FIG. 2—On this chart, for September 28, 1921, a successful forecast of fair weather for 14 days was based.

the *Geographical Review*, Vol. 10, 1920, page 38. It would add greatly to the value of the present daily weather information if such a northern hemisphere map in reduced and convenient form, prepared jointly by the Hydrographic Office and the Weather Bureau, were made available.

It would moreover mark a decided step forward, if in addition to the storm tracks the intensity and travel of "highs" were shown. Not until this is done will the accuracy of forecasts be much improved. One advantage of such far-flung charting is that slow-moving

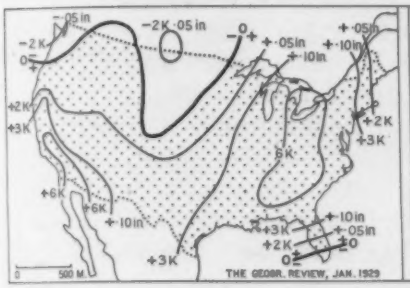


FIG. 3

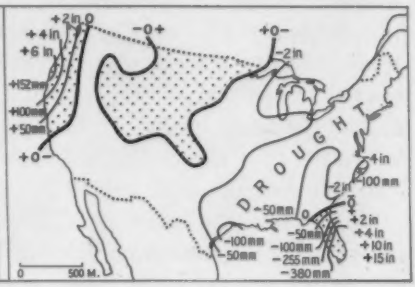


FIG. 4

FIGS. 3 and 4—Drought conditions over the eastern half of the United States at the beginning of October, 1924. Figure 3 shows pressure excess in kilobars and equivalent hundredths of inch. Figure 4 shows rainfall deficit in millimeters and equivalent inches.

"highs" are instantly noted and the forecaster may anticipate a consequent slowing down of the following "low." Incidentally it would encourage the forecaster to venture a long range forecast. For example, Figure 2 illustrates a forecast for 14 days in advance made in the Meteorological Office at 7 a. m., September 28, 1921.[2] No rain fell in London for two weeks. A forecast of much greater moment, however, might have been made at the beginning of October, 1924, for the eastern half of the United States (Figs. 3 and 4). It was evident that a steady inflow of polar air and an absence of warm moist southerly winds were leading to the building up of a "stagnant high," as it is technically called. That is, the hyperbar then resting over the eastern half of the continent was preventing the passage of both northern and southern "lows." Plainly the chances were all against a normal rainfall from the Mississippi Valley to the Atlantic, with the exception perhaps of Florida. As a matter of fact that month was the driest October on record, and some of the records ran back for 100 years. Figures 3 and 4 show clearly the interdependence of rainfall and pressure excess.

During the prevalence of the hyperbar (a stagnated excess pressure) "lows" could make no headway eastward; and, what is of direct significance, a tropical cyclone (or West Indian hurricane) could not advance north. The storm over the northwestern Caribbean

[2] Sir Napier Shaw: Forecasting Weather, 2nd edit., London, 1923, p. 181.

Sea, October 13 to 18, was held in position, the usual resultant directive force toward the northwest being ineffective. The rotational energy was not diminished; and hence some of the lowest pressure readings ever recorded in that region, famous for low pressures at hurricane centers, occurred. A land station reported 932 kilobars (27.52 inches), and various ship reports indicated 950 kilobars or less (28 inches). The hurricane being thus in a measure stationary, the rainfall was unusually heavy. At Miami the total for the month was 635 millimeters (25 inches), or 400 millimeters (16 inches) above the normal rainfall for October. In the Porto Rican hurricane of September 12 to 20, 1928, we can trace clearly the influence of the "high" over the North Atlantic States in determining the point of recurvature and subsequent north and westward movement of the hurricane. We note also the heavy rainfalls along the coast from Florida to Virginia, owing to the blockade.

This hurricane has started discussion of the possibility of dissipating approaching storms by some sort of trigger action whereby the stratification incident to increase of thermal energy can be prevented or broken. Some idea of the magnitudes involved in the displacement of air masses in an ordinary depression can be obtained from the data given later in this paper. At present little more can be said than that, regardless of theoretical considerations, we have no means of interfering with or breaking up storm structures. The forces involved are so stupendous that the effort would be comparable to that of attempting to sweep back an incoming tide with an ordinary broom, or even many brooms. On the other hand we can detect the existence of conditions favoring the formation of a hurricane, and we do anticipate the path with a high degree of accuracy.

## Relation to Flood Forecasting

A natural question arises at this point. Can this knowledge of the pressure-precipitation relation be used in forecasting floods as well as droughts? We think it can; but the problem is different, though essentially less difficult. A sharp distinction must be made between heavy rainfalls and floods. True, no flood can occur without a preceding heavy rainfall, but the converse does not follow. In a large drainage basin like that of the Mississippi an excessive volume of water may pass through the waterways without damage or culminating in overflows, provided various factors operate in unison. The memorable floods in the Mississippi Valley in 1913, 1922, and 1927 were the result of saturated ground, previous heavy rains, flood crests in the northern tributaries, and a synchronism of the crests with heavy rains in the lower reaches. The breaking of protective levees and the formation of crevasses followed. It is estimated by

Frankenfield[3] that the total rainfall from January 1 to April 30, 1927, for the entire basin was 213 cubic miles. This is about a million tons of water, the bulk of which must hurry to the Gulf. If the delivery can be slowed down by means of storage basins and by-passes, overflows *can be prevented*. This water, however, was at some time lifted to a height of at least 1000 meters, which gives us a mental picture of the work done by air currents in the making of rain clouds. Sir Napier Shaw, it may be noted, has given an estimate of the energy in a depression over the North Sea, July 27 to August 3, 1917, thus: diameter of depression 1400 kilometers; depth at center 10 kilobars; quantity of air removed to allow for depression 70,000,000,000,000 kilograms; quantity of water vapor 700,000,000,000 kilograms, with resultant kinetic energy developed, $1.5 \times 10^{24}$ ergs.

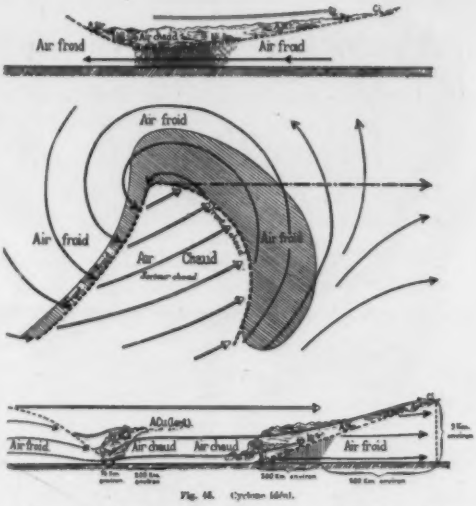


FIG. 5—Polar Front Scheme, for origin of cyclones. Bjerknes and Solberg.

## THE UPPER AIR AND MODERN METEOROLOGICAL THEORY

This brings us to the problem of how best to record and interpret clouds, with the best presentation on daily weather maps. The fact that we now are able to determine the direction and speed of the air at cloud levels, ought to be of great assistance in the making of forecasts. Also a steadily increasing number of reports giving the temperature gradient with elevation—or, as it is called, the lapse rate—lets us sound the air, as it were, and map the upper strata.

European aerographers pay much attention to what is called the polar front. Both name and theory are due to Professor V. Bjerknes. This front is the surface of discontinuity between cold air from polar regions and warm air from the equatorial regions. "Lows," or depressions, develop at this surface. Cold air pushes forward under warm air, and warm air rises over cold air in its front. The general scheme is shown in Figure 5. The shaded part of the figure indicates the rain area. As Ernest Gold has said:[4] "The outstanding advantage of the theory is the light which it throws on 'development.' By its

[3] H. C. Frankenfield: The Floods of 1927 in the Mississippi Basin, *Monthly Weather Rev. Suppl. No. 29*, 1927.

[4] Quoted in Sir Napier Shaw: Manual of Meteorology, Vol. II, Cambridge, 1928, p. 388.

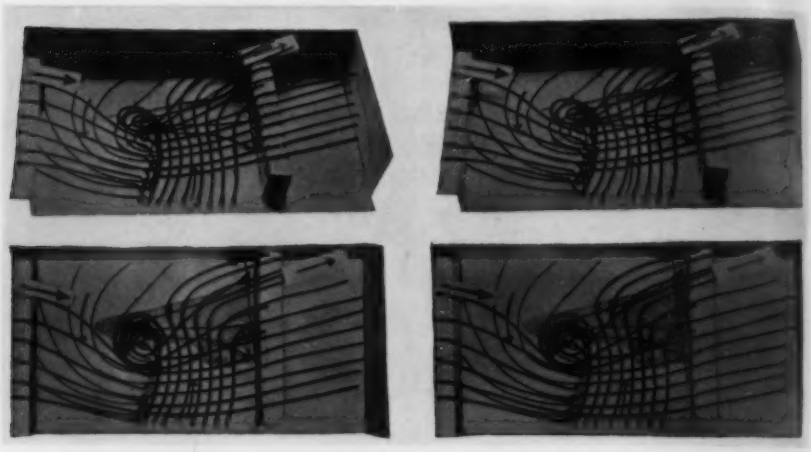

FIG. 6—An illustration from Sir Napier Shaw of the three-dimensional study of the air.

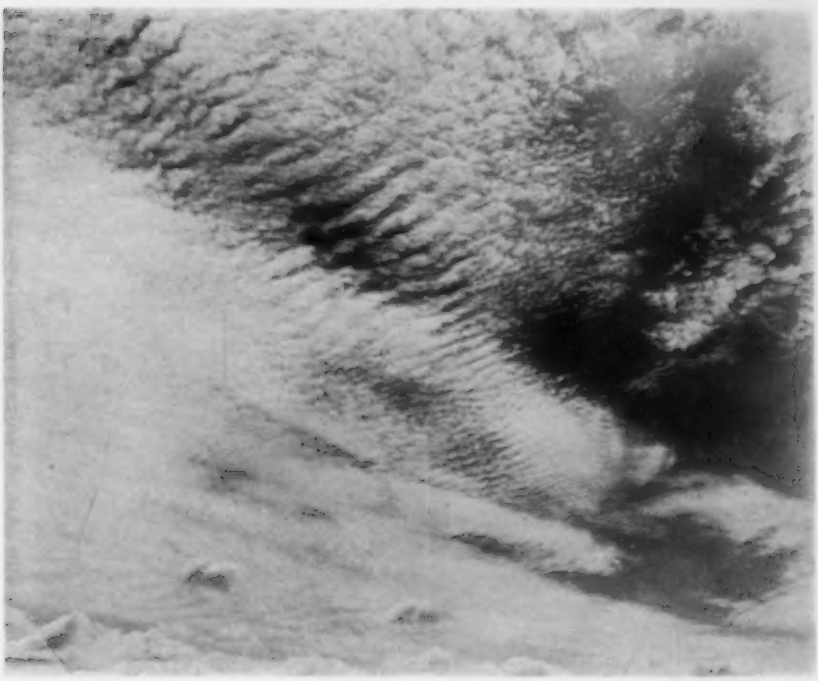

FIG. 7—Clouds showing stream lines in convection and stratification.

aid the forecaster can now see how an existing cyclone will develop; whether it will go on increasing in intensity, or if it will become stationary and fill up; he can also see where a new cyclone is likely to develop *before any actual development has commenced.*"

It is only fair to say, however, that, as tried in the United States,

conditions do not always conform to what the theory demands. Unfortunately we have but little information about the rate of ascent of air, warm or cold, dry or moist; and until we get this "our ideas about the inner life history of a cyclone are necessarily crippled." "Our cyclones are cold in the core, cold-hearted creatures, not the warm-hearted figments of the meteorological imagination of the past 60 years, and that indubitable fact means that they had been formed before they reached us. It was unnecessary and therefore unwise to think of the processes which the meteorologists detected as soon as they had maps to work with, as being the agencies for the making of cyclones; we should have been better advised to think of them as agencies for the destruction of those creatures."[5]

Figure 6 is a photograph from a model showing stream lines of convection in a vortex superimposed upon a uniform current of air at the level of the fourth kilometer with a retardation of motion at the surface, thus "featuring" the cyclonic depression of November 11–13, 1901. This photograph was kindly sent to the writer by Sir Napier Shaw. It appears also in the "Manual of Meteorology," Volume II, page 405. The stippled area in the lower figures (rather faintly shown) indicates rainfall with reference to the center of the low at the surface. We are looking down on the stream line in the lower set, and at an angle of 30° in the upper set.

Figure 7 illustrates various air stream lines, both horizontal and vertical. The upper cirro-cumuli and alto-stratus have numerous small cumuli below, indicating that convection may occur with stratification.

From these examples it is obvious that certain additional data should now be presented on our daily weather map. We must reach upward as well as enlarge the horizon.

[5] *Ibid.*, p. 404.

# MAJOR WORLD SOIL GROUPS AND SOME OF THEIR GEOGRAPHIC IMPLICATIONS

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*Columbia University*

THE development within the last half century of a science, pedology, which deals with the soil as a natural body, has opened a vast area of uncorrelated geographic material. It is the purpose of this paper to indicate certain tentative landmarks therein.[1]

Although soil is one of the major elements of the environment and its importance is appreciated in a general way, its rôle has not been fully understood. It shares its influence upon plant life with climate and, since climate is more or less familiar and its effects are relatively easily understood, the real significance of the soil is often overlooked in the effort to set forth the climatic relationships. The soil, in contrast to the climatic environment, is extremely complex; and little was known until recently with regard to its fundamental characteristics. It had been studied largely from the standpoint of its relationships to the materials from which it is evolved and to the method in which these materials accumulate, but little or no attention was given to the properties of the soil itself.[2]

## Soil Characteristics

Soils have chemical, physical, and biological attributes. Limits of space prevent any but the briefest references to several of the more striking key characteristics to which subsequent attention will be directed. These include color, structure, and certain chemical and profile phenomena. Texture is omitted, since the reader is undoubtedly familiar with the nature and meaning of this important qualification.

Soil colors, outside of identification, are often indicative of other significant properties, viz. the proportion of organic matter present, the tilth conditions, etc. They embrace two general classes: (1)

[1] The facts here presented, upon which the geographic generalizations are based, represent the work of many investigators in addition to that of the writer—especially that of his coworkers in the U. S. Bureau of Chemistry and Soils as well as numerous soil scientists of other countries. The writer is chiefly indebted, however, to Dr. C. F. Marbut, whose keen and untiring mind built up much of the framework of modern soil science and whose generous personal concern in his field of interest has been a constant source of inspiration.

[2] H. L. Schantz and C. F. Marbut: The Vegetation and Soils of Africa, *Amer. Geogr. Soc. Research Ser. No. 13*, 1923, pp. 115–117.

dark colorations, such as blacks and dark browns, and (2) light colorations, the tints ranging through reds, browns, yellows, and grays. As a rule dark colorations characterize soil material high in organic matter, the black humus compounds masking the lighter mineral particles.[3] Such soil material is usually fertile, is easily tilled, and has an abundant supply of nitrogenous substances. Light-colored material tends towards opposite characteristics, being low in humus and less amenable to good tillage. The light colors represent chiefly iron in several states of oxidation and reduction, commingled with small amounts of decomposed vegetable matter. Soil colors are usually acquired characteristics; in only exceptional cases are they inherited from the parent material.

Soil structure refers to the arrangement of the individual particles (clay, silt, and sand) as larger aggregates or bodies. A variety of forms are assumed—blocklike, cloddy, nutlike, granular, columnar, platy, etc.[4] Their geneses are also the results of soil-making processes, this feature being one of the more striking physical properties.

From the standpoint of agricultural economics the structural properties of soil material exceed all others in importance, especially in soils of heavy texture. Those of poor or imperfect structure are hard and refractory when dry, plastic and intractible when wet, and form lumpy, cloddy surfaces when turned in plowing. Their natural drainage is poor, and they are unresponsive to fertilizers. Soils with good structure, on the other hand, form smooth, crumbly seed beds, the upturned masses breaking down readily along the cleavage planes of the structural particles (Figs. 1 and 2). For instance clay soils, popularly classed as heavy and refractory, may crumble like sand, provided they have good structure. Some such soils may even be plowed when in a saturated condition.[5] These soils, moreover, have good internal drainage, as water easily penetrates the interstructural air spaces. As the majority of crops require well drained soils, the disposition of surplus water is necessarily important. The relationship of good structure to fertilization is of equal, if not greater, significance. Infertile soils with favorable structure may be profitably fertilized. Soils with poor structures, however, are unresponsive and, contrary to the prevailing belief, cannot be made productive by the mere addition of proper fertilizers. A favorable structure is more important than the presence of potash, phosphorus, and other so-called plant foods since structure appears to be extremely difficult, if not impossible, to correct, especially over large areas.

[3] J. C. Russell: Variations in the B Horizon, *Rept. 8th Ann. Meeting Amer. Soil Survey Assn.*, pp. 100–113.

[4] The structural types were interestingly summarized by the Russian pedologist, S. A. Zakhorov, who presented a systematic classification to the First International Soil Congress.

[5] See, for example, "Sharkey clay," pp. 985–989 of F. Z. Hutton and Others: Soil Survey of Coahoma County, Mississippi, *U. S. Dept. of Agric., Field Operations of the Bur. of Soils, 1915* [*17th Rept.*], pp. 973–997.

Soil material of sandy texture is usually without structure, the unit particles being largely composed of single grains; but the deficiency is economically unimportant. This textural class is naturally very friable and usually possesses good internal drainage. Most sandy soils, moreover, appear to be responsive to fertilizers.

FIG. 1—A fairly coarse or nutlike structure of soil material, the shaded cavities indicating the size of the larger aggregates. When plowed the soil mass breaks down naturally along its cleavage lines. These fractures are also natural internal passageways for air, water, and roots.

The chemical characteristics of soil material may be viewed under two heads, reaction (acidity and alkalinity) and composition, although the former is a function of the latter. Acid soil materials are markedly unlike those of neutral or alkaline reaction. They are deficient in available bases, particularly calcium; their structure is coarse or imperfect; and fertilizers are essential for optimum crop-growth conditions. Soil materials of alkaline reaction, on the other hand, possess all, or a large number, of the more desirable soil properties.

While the more abundant constituents of soil material are the compounds of silicon, aluminum, and iron, the most notable component appears to be lime, or calcium carbonate. Important physical, as well as chemical, characteristics seem related to its absence or presence in comparative amounts. Soils low in lime are acid in reaction, while a high lime content is necessarily associated with alkalinity. Good structural development is also dependent upon the presence of lime, and, where conditions favor the accumulation and incorporation of appreciable amounts of organic matter in the soil, lime seems to be essential to its retention in the soil material.

Like other natural objects, soils show anatomical organization. The divisions are called zones or horizons, the terms being preferable to layer, as the change from one unit to another is usually gradational and not abrupt as in layers or strata. The peculiar nature and thickness of each horizon, as well as the features of its subdivisions, give a soil its character and constitute the bases upon which soils are not only differentiated from one another but are also distinguished from other earthy accumulations popularly referred to as soil. The

latter do not constitute soil in the scientific sense because they are without the properties which characterize the great mass of those bodies covering the earth's surface.

The bases of subdivision into horizons are several. They include color, structure, texture, chemical composition, porosity, and other soil characteristics. The divisions with respect to any one property may or may not be identical with zones of another property, color zones often overlapping structural and textural horizons.

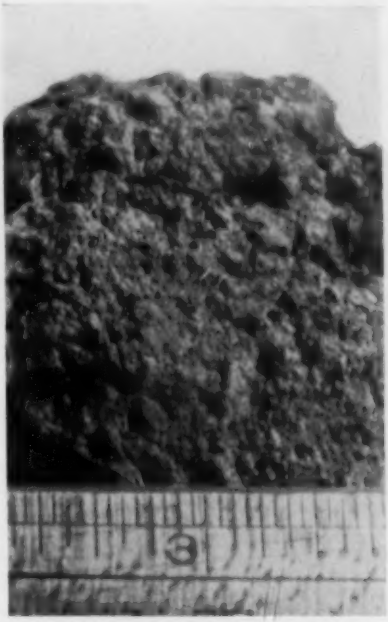

FIG. 2—The fine granular structure of one of the chernozems, southern Nebraska. The many small aggregates enable the mass to break down into the finest, smoothest seed bed. Root and water penetration are easy.

The normal soil profile reveals three major divisions—A horizons (soil), B horizons (subsoil), and C horizons (substratum) (Fig. 3).[6] The A horizons include the upper part of the soil mass from which material has been removed by percolating waters, in either a chemical or physical way, during the process of soil evolution. In humid climates these horizons are normally lighter in texture than the B horizons, are comparatively high in silica, and have a chemical composition wholly unlike that of the B and C horizons. Similar differences also exist in the soils of lower rainfall climates, but with less striking chemical and textural contrasts.

The B horizons are those of deposition, the zones to which material has been added by percolating waters. Those developed under humid climates are also low in alkalies and alkaline earths, but they are comparatively heavy-textured and high in certain iron and aluminum compounds. The C horizons comprise the relatively unweathered zones underlying the B horizons. The material, in most cases, is presumably similar to that from which the soil was evolved. It is often referred to as "parent material," but its chemical and physical properties are markedly different from the true soil or solum above it.

## EVOLUTION OF SOILS

The manner in which soils are evolved and the explanation of the characteristics they acquire are largely a concern of pedology. Geog-

[6] As the terms soil, subsoil, and substratum are somewhat loosely employed, soil science has adopted the letters A, B, and C for its divisions.

raphers are interested, however, in the philosophy underlying modern soil science, as it serves to make clearer the soil's geographic relationships.

The belief that a soil's fundamental characteristics are inherited from, or closely related to, the parent material from which a soil was derived and the manner in which this material was accumulated, is a concept of long and almost universal standing. The assumption, in fact, is the basis for the several so-called kinds of soils—limestone, loessial, glacial, residual, etc., the modifier presumably indicating some notable characteristic of the soils in addition to the nature of the parent material. Limestone soils are supposed to be rich in lime; sandstone soils, poor and impoverished; alluvial soils, fertile and of good texture because "mixed."

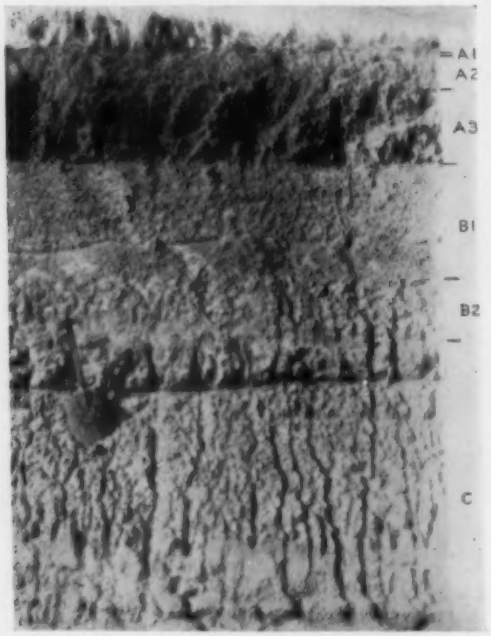


FIG. 3—Soil profile of the Hastings silt loam, one of the black earths, southern Nebraska, whose natural vegetation is long prairie grasses. The surface soil, darkened in color by decayed organic matter, has three subdivisions. $A_1$ horizon is grayish brown, structureless dust mulch, less than one inch in thickness, very fine sandy loam to silt loam in texture. $A_2$ horizon, about three inches in thickness, is made up of small, very dark grayish brown platy forms so disposed as to give the horizon a minutely layered appearance. $A_3$, dark grayish brown material, about eighteen inches in thickness, is characterized by granular structure.

The subsoil, or B horizon, has two divisions. $B_1$, the zone of maximum compaction, is not impervious, however, and is composed of grayish brown material markedly granular in structure. $B_2$, light grayish brown or yellowish structureless silt, is the zone of lime accumulation (white spots and splotches throughout the mass and soft or hard concretions).

The C horizon, or parent material, is silty, gray plains loess, generally without structure.

Field and laboratory studies do not confirm a general relationship between soil characteristics and parent material, however. The Hagerstown series, the dominant soils of the famous Shenandoah Valley and the Kentucky Blue Grass Region, for example, are derived from limestone; but they are not only benefited by lime applications but may also give acid reactions.[7] Large tracts of Mississippi's upland soils are derived from rich wind-blown loessial materials, but the soils are light-colored and acid. They have heavy compact water-

[7] See, for example, "Hagerstown stony clay loam," pp. 450–451 of J. B. R. Dickey and W. B. Cobb: Soil Survey of Frederick County, Virginia, *U. S. Dept. of Agric. Field Operations of the Bur. of Soils*, 1914 [*16th Rept.*], pp. 429–472.

obstructing subsoils. Fertilizers are used for corn and cotton, and the application of two tons of ground limestone per acre has proved beneficial.[8] In contrast are the loessial soils of central Nebraska and Washington.[9] Lime is accumulating in the B horizon, no fertilizers are used, and the normal soils are without compacted impervious subsoils. This type of discordance is general, not exceptional.

Of equal import is the widespread existence of great tracts of soils with similar fundamental characteristics, although derived from unlike geological formations. Glacial, loessial, and residual deposits constitute the dominant soil-forming materials in the upper Mississippi Valley, but great bodies of essentially like soils, with little or no regard to the underlying rock débris, have nevertheless developed. Differences of detail, of course, exist; but these dissimilarities are no greater than those prevailing among the land forms which the soils occupy or the natural vegetation which once mantled them. A convincing example is that of the *chernozems*, or black earths. These soils are not only widely separated but have developed from material accumulated in various ways and derived from many different kinds of rocks; yet their fundamental characteristics are the same.

FIG. 4—A typical non-lime-accumulating soil, the Sassafras very fine sandy loam on the Delaware Coastal Plain. This soil belongs to the brownerths, the brown humid soils developed under forest covers. The excavated shelves indicate the depths of the several major subdivisions. There is no marked color difference between the A (soil), B (subsoil), and C (parent material) horizons; but the B horizon is compact and relatively dense, although sandy-textured. It consequently "holds back" water and is much more drought-resistant than soils composed largely of coarse, non-compact materials.

These soils are low in lime, nitrogen, phosphates, and potash but are heavily fertilized for trucking and fruit farming since they are close to urban markets. The compact B horizon is again an asset in that it prevents the overrapid leaching of the costly fertilizers. As the C horizon is comparatively light in texture, the soils not only have the excellent underdrainage required by most truck crops but also dry out and become warm early in the spring.

[8] E. Malcolm Jones and E. P. Lowe: Soil Survey of Alcorn County, Mississippi, *U. S. Dept. of Agric., Field Operations of the Bur. of Soils, 1921 [23rd Rept.]*, pp. 673–705; reference on pp. 688–689.

[9] See F. A. Hayes: Revision of the Grundy Series of Nebraska, *Rept. 8th Ann. Meeting Amer. Soil Survey Assn.*, pp. 86A–99. Dr. G. E. Condra, Director of Nebraska Surveys, is the leading authority on the loess formation of Nebraska. His recent findings and interesting conclusions regarding its origin are not yet published.

It is now recognized that the significant factors to which the basic features of soils may be attributed are the agents which further modify the accumulated materials from which the soils evolve. These produce physical as well as chemical changes. They bring about the decomposition of the minerals forming the rock waste. They effect the translocation of substances within the soil mass. They cause new structures, such as granules or nutlike bodies, to be formed. They develop the biological relationships of the soil. In short, they evolve a new entity—a body of matter quite unlike the original rock débris.

FIG. 5—Young Gloucester soil developing from coarse morainal deposits, Long Island, New York.

Climate is by all odds the most important factor, as it conditions, over large areas, the temperature and moisture under which the complex changes in the rock débris take place. The effect of other factors—the natural vegetation, the soil fauna, the land forms which the soil occupies, and others[10]—is secondary. The influence of the parent material is merely manifested, to any degree of importance, in its textural relationships, the clay and sandy types being derived from materials respectively low and high in silica.

## CLIMATIC SOIL GROUPS

While soils are rarely uniform over extensive areas as respects minor features, yet great belts exist in which they have from few to many significant features in common. These soil groups are of peculiar interest to the geographer, especially in their larger connections.

The close relationship between soil and climate has brought about the development of great groups of soils whose distribution is roughly coincidental with the world's leading climatic types. The groups are not defined on the basis of their occurrence within the climatic regions, however, but on the characteristics which they themselves have developed, that is on the basis of soil characteristics and not on that of climatic phenomena.

The broad fundamental features of the soils of each group are essentially similar. As climate is the most powerful soil-forming agent

[10] The rôle of climate and other factors which play important parts in soil evolution are to be the subject of a paper under preparation by the writer.

and its conditions prevail over large areas, and since most soil-forming materials contain the same or equivalent chemical and physical compounds, extensive bodies of like material are subject to the same potent influence.

Each group has soils in various stages of development, however, owing to the influence of secondary factors; and appropriate age subgroups are recognized, such as young, mature, and aged. Young soils have rudimentary profiles (imperfect A and B horizons), are more or less like geological formations, and occupy hillsides and flood plains where they are subject to rejuvenation by erosion or deposition. Mature soils have well developed profiles, most of the chemical and physical changes to which they are subject having taken place. They are adjusted to their environment and occupy smooth, level areas where they are relatively undisturbed by erosion and deposition. Old soils typically evolve on flat surfaces where environmental conditions have long been stable. They have lost the essential features of maturity. Many soils in old age, for example, develop tough, indurated B horizons.

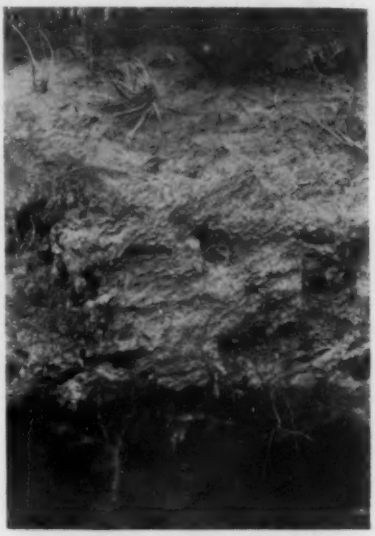

FIG. 6—A New England podsol. The A horizon is the light-colored—grayish, nearly white—zone, structureless and thoroughly leached. The B horizon is the dark-colored zone—brown or coffee-colored—in which iron oxide and organic matter have been precipitated.

## THE MAJOR SOIL DIVISIONS

The great climatic soil groups form one of two major soil divisions[11]—those which have lime accumulations at maturity and those without such accumulations, these features being curiously developed regardless of the nature of the parent material from which the soil was derived. The former have some zone, usually the lower part of the B horizon, in which lime appears in greater proportion than in any other division of the profile. The latter group has no horizon in which calcium carbonate accumulates. In fact, the typical mature soils are low in lime and acid in reaction. They normally develop under forest covers, the lime-accumulating group occurring under grassland and desert associations. These major soil divisions are analogous

[11] A comprehensive scheme of soil classification has not yet been perfected and generally adopted. Dr. C. F. Marbut, however, has proposed an admirable system embracing seven categories, each division of which is based not on genetic relationships but upon the characteristics of the soils themselves. See Bennett and Allison: The Soils of Cuba, pp. 341–354.

to the plain-plateau and mountains of physiography, the flowering and nonflowering plants of botany, or the vertebrates and invertebrates of the animal world. They are characterized by a simple and easily recognized feature—the absence or presence of a zone of lime accumulation.

Following the usual procedure in the natural sciences, the geographic and other generalizations made in this paper are all drawn with reference to the dominant mature soils of each group, except where properly qualified references are made to certain young soils of unusual moment.

## The Non-Lime-Accumulating Soils

While this division of soils is defined on the basis of a single unqualified characteristic, other broad generalizations may nevertheless be noted. The mature soils are usually light in color—grays, yellows, reds, and light browns. They are commonly low in potash, nitrates, and phosphates. Their structure is not finely granular but coarse, nutty, and cloddy. From the agricultural standpoint, this major division of soils is less fertile than, and inferior to, the lime-accumulating soils. Important differences, nevertheless, exist between the several groups which constitute the larger unit. The more important members include the laterites, *podsols*, *rederths*, *gray-brownerths* and *prairyerths*. Soil literature, in common with other young sciences, is still deficient in acceptable terminology, no suitable phrases or single names existing for many important processes, soil groups, characteristics, etc. The two Russian group names, *podsol* and *chernozem*, are in general use and have been found satisfactory. But the red forest group, the brown forest group (Ramann's Braunerden), the semiarid chestnut-colored group, the gray desert group, and the prairie group are not acceptably designated. These phrases include vegetational, climatic, and color qualifications employed without consistency. The writer accordingly proposes the terms *rederths*, *gray-brownerths*, *chestnuterths*, *grayerths*, and *prairyerths* for the respective divisions, the names corresponding to the Russian chernozem (black earth).[12]

## The Laterites

The hot rainy tropics represent one of the world's extreme types of climates. Temperatures are high, and the rainfall is heavy during much of the year. The native vegetation is broad-leaved evergreen forests, and a relatively dense canopy shades the forest floor. The forest litter does not collect as undecayed organic matter, however, but decomposes rapidly.

[12] The names were submitted for criticism to Dr. Marbut. In the absence of a thoroughly scientific scheme of nomenclature, he deemed them appropriate and acceptable.

The normal soils of these regions—the laterites—are very striking. They are usually red in color and are quite thoroughly leached. Under the influence of heavy rainfall and high temperatures, the mineral matter of the original parent material has been largely broken down. Iron and aluminum are concentrated in the B horizon, but the critical soluble plant foods have been dissolved by internal drainage waters and carried out of the solum. In spite of the heavy forest cover, the organic matter or humus content is slight. The soils are very low in lime and acid in reaction. They are deficient in potash and phosphates. They are "poor" soils. The structure, however, is coarsely granular or nutlike: and the soils are friable, break up readily, and form fairly good, though not ideal, seed beds.

Even in the virgin[13] state, the laterites are not well suited to farming—particularly commercial agriculture. When cleared, the soil is in early, if not immediate, need of fertilization and will not endure continuous cropping without the most careful and persistent attention. Both lime and organic matter are required since the forest mold and the soil structure are subject to rapid disappearance under cultivation.[14] Most of the natives practice only a crude patch or garden agriculture in forest clearings. As the soils are so low in the critical elements of fertility, land abandonment and new clearings—a nomadic agriculture—are consequent characteristics of the native practices. Only the fresh young soils of the flood plains or the constantly rejuvenated soils of the hilly areas are continuously usable without heavy fertilization; but these situations create problems of flood control and soil erosion.

The climatic conditions under which the laterites develop are excellent for plant growth; but these very characteristics make them unfavorable for the development of soils which are naturally good agriculturally. They are also disadvantageously located from the standpoint of health and sanitation. The dual handicap has been generally inimical to the support of even a moderate population. The soils seem capable of supporting a greater number, however, provided the food supply be confined largely to low-latitude produce. At present, population density has attained only a noteworthy figure on young unleached soils of the river valleys or freshly rejuvenated hill or mountain soils.[15] Here moderate to dense populations may find conditions adequate for maintenance. These situations are also utilized for plantation agriculture by foreign capital.

[13] Only virgin soils, i.e. soils as they exist naturally, are described in this paper. Modifications brought about by man—such as plowing, fertilizing, leveling—destroy or alter the natural characteristics.

[14] C. F. Marbut and C. B. Manifold: The Soils of the Amazon Basin in Relation to Agricultural Possibilities, *Geogr. Rev.*, Vol. 16, 1926, pp. 414–442.

[15] Soils on slope lands are generally less leached than those mantling the smooth uplands due to erosion.

## The Podsols

Coniferous forest constitutes the dominant natural vegetation of much of central and northern North America and northern Eurasia. The typical mature soil of this environment is whitish or gray in the surface horizon and has been given the Russian name, *podsol*, the age-old folk term applied to the gray soils of northern Russia.[16]

The climate is wet and cool with long frozen winters and relatively brief summers. The short summers do not promote rapid mineral decomposition, but the mature soils are nevertheless leached and impoverished as the rains of this season readily dissolve the small amount of soluble materials formed. The immediate surface of the virgin soil is dark, owing to the accumulation of raw humus from the fallen vegetable débris, but the underlying horizon is gray or whitish because of the removal by the percolating acid waters of iron oxides. It is structureless and powdery when dry.

The soils are acid and deficient in organic matter. Raw humus lies *on* the surface, but the dense shade of the timber cover and the cool moist climate are not conducive to the existence of the soil organisms that ordinarily assist in its decomposition and bring about its incorporation with the soil. The organic compounds break down eventually, though slowly, but the soluble substances are swept, with small amounts of the other materials leached from the surface, to the zone below the white, grayish A horizon and there precipitated. The solum, in a sense, therefore, is upside down, as the organic matter is "under the soil." This zone in which the organic matter has been deposited is typically brown or coffee-colored. It is sometimes indurated, the hardened zone forming the so-called *Ortstein* of the German literature. The podsols, however, are normal soils which are widely developed and should not be viewed as abnormal or unnatural.

The podsols, like the laterites, are not "strong soils" under cultivation. Manuring or fertilization is necessary for continued successful cropping.[17] The acid conditions call for heavy applications of lime. Phosphatic, nitrogenous, and potassic fertilizers must also be applied. The lack of structure makes the mature soils of heavy texture dense and difficult to manipulate. The soil bakes and forms extremely hard clods if plowed when too wet.

The system of agriculture, especially in the more backward areas, is not far removed from, if not essentially similar to, the patch agriculture of the laterites. Nature's landscape still dominates over the cultural landscape of man, the farmed areas being scattered here and there through the forest. The short growing season is a further limitation; the chief staple crops produced are those suited to both soil and

[16] The name is derived from the Russian word *sola*, meaning ashes.

[17] See L. A. Hurst and Others: Soil Survey of the Aroostook Area, Maine, *U. S. Dept. of Agric., Field Operations of the Bur. of Soils, 1917* [*19th Rept.*], pp. 7–46; J. O. Veatch and Others: Reconnaissance Soil Survey of Ontonagon County, Michigan, *ibid., 1921* [*23rd Rept.*], pp. 73–100; and others.

climate, such as rye, barley, and potatoes. In fact, the soils are not far from the present margins of economic production. They are employed largely for subsistence agriculture. Commercial crops are confined to a limited production of specialties, like potatoes (Maine), or dairy products where good access to markets exists (Finland). Many regions having this group of soils are nearly uninhabited, the natives spending much of their time in hunting and fishing.

## The Rederths

The rederths embody the podsolic red forest soils of the middle latitudes. These soils have certain features in common with the lateritic[18] red loams of the tropics, but the subsoils of the latter have a pronounced zone of iron oxide accumulation in which impure bodies of iron are segregated. In this paper the two are described together, owing to their general geographical similarity and the fragmentary data available on the tropic soils.[19]

The normal rainfall under which these soils develop is fairly heavy, and the temperatures average well above freezing; but the mature soils are not as thoroughly leached as the true laterites or podsols. The A horizons, under virgin conditions, are generally yellowish, gray, or faint reddish, although stained in the upper part by organic matter. They are overlain, in forest environments, by thin layers of leaf mold and undecomposed leafy materials. The B horizons, however, are red. Since the thin dark-colored surface is intermingled with the substructure in cultivation or is often eroded away, the fields are reddish in color, and the soils are qualified in accordance with this tinge.

The mature soils have a low but significant content of nitrates, lime, potash, and phosphorus.[20] The structure of the finer-textured rederths is moderately coarse and fairly well developed; that of the red loams about which published information is available is exceptionally well developed, the soils being remarkable for their ready friability and great porosity, even where the types are the finest of clays.

While the growing season of the climates in which these soils occur is interrupted in the tropic areas by a dry and in the middle latitudes by a cool season, the crop adaptation from the climatic standpoint

[18] Podsolic soils are podsol-like soils; they have been subject to the same soil-forming processes which produce podsols. Lateritic soils are laterite-like soils in the same sense.

[19] See, however, Shantz and Marbut, *op. cit.*, pp. 127–128 and 192–208; Bennett and Allison, *op. cit.* The area of distribution of the rederths includes large bodies of soils whose subsoils are yellowish. The yellowerths occupy relatively flat lands and are less perfectly drained but have the same general agricultural relationships.

[20] Not all soils of this group are low in potash: the red Cecil soils of the southern Appalachian Piedmont have a high potash content. See R. C. Jurney and Others: Soil Survey of Guilford Country, North Carolina, *U. S. Dept. of Agric., Field Operations of the Bur. of Soils, 1920 [22nd Rept.]*, pp. 167–199; reference on pp. 176–177. There are also local variations in respect to the other elements named.

is nevertheless comparatively large. The soils, as a whole, are not highly productive in their natural condition, however. They are not well adapted to important grains like corn or nutritious pasture grasses capable of producing meat of high quality. The low nitrogen content is disadvantageous in cereal culture, and the acidic conditions to calciphilous crops, such as alfalfa and blue grass.

The normal red loams about which we have information are unusual in the extent to which they seem capable of prolonged cultivation without apparent noteworthy deterioration. The virgin rederths of middle latitudes have not been amenable to continuous cultivation, however, without early degeneration. Fertilizers are necessary; and seminomadic methods are locally in practice, as the soils decrease rapidly in productiveness. New fields, for example, are frequently brought under cultivation in the North American Cotton Belt. The restricted fertility is an economic imperfection of great geographic significance, as the rederths occupy belts on the borders of the tropics. Here climate is less enervating to man than in the hot, wet tropics, but curtailed productiveness of the soil is a limit to agriculture or burdens it with a heavy cost of fertilizers; and these qualifications react upon population which has reached a high density only under favorable local conditions or at the expense of living standards.

While the virgin rederths as a group are naturally more fertile than either the laterites or the podsols, their use for commercial agriculture has not been proportionate to their greater fertility. The commodities produced for export are chiefly the fruits of fertilized or young and better soil bodies included in the general area. The leading products, moreover, are largely specialties—cotton, tea, peanuts, coffee, bananas, sugar—although there are limited amounts of staple food crops like rice.

The occurrence of a large part of densely populated China in the region of the rederths is of unusual interest in view of the natural low fertility of the group. These peoples make little or no use of their mature upland soils, however, but are crowded along the rivers. The floods are tragic; but the soils are young, fresh, and tillable and are periodically renewed. The natural productiveness is further increased by the extensive use of fertilizers.

The population, outside of the flood plains, is in hill and low-mountain country, whose slopes have been laboriously carved into terraces. Their soils (if we may base judgment on studies made in this country) are also pedologically immature. They were constantly rejuvenated in their natural state by erosion, and if man's use has tended to decrease their fertility it has probably been offset to some degree by the general use of fertilizers. It should also be noted that the soils occur in a region which is a more or less common meeting ground of a good food-producing climate and a fair "man climate,"

that is with stimulating winters. The combination is a geographic alliance of the first magnitude. There is no reason why the industrious Chinese should not be farmers for forty centuries.

The North American Cotton Belt, with which China is so frequently contrasted agriculturally, is largely a region of mature soils, however, with the noteworthy exceptions of the flood plains of the Mississippi and local areas of hill and limestone country. A high proportion of the soils, moreover, are prevailingly sandy. From the standpoint of productiveness, therefore, the soils as a whole are quite inferior to the young unleached soils of China. The reader is reminded that comparisons or contrasts noted in this paper are *regional*, not local qualifications. Soil regions differ locally as widely as vegetational, major land-form, and other larger groupings.[21]

The fundamental difference in the types of soils used for agriculture in China and the Cotton Belt has not been generally taken into account by the innumerable writers who have enthusiastically pointed to China's agricultural success as a "model" for the North American Gulf States. The American farmer, however, began his "struggle" and is still struggling with soils which were fundamentally poor and will always require fertilizers, while the Chinese had, and apparently still have, young productive and unleached soils.

## The Gray-Brownerths

The cool humid lands of northwestern Europe and the northeastern United States, with long growing seasons and relatively short frozen or frosty winters, also develop podsolic soils; but these are light brown to grayish brown in color and are less leached and less acid than any of the soil groups heretofore mentioned. The gray-brownerths are also widely developed in Pacific America, the Mediterranean world, and elsewhere. It should be observed that the exact location of most of the soil groups named in this paper is not known, with the exception of those occurring in Europe and the United States. Little or no detail mapping has been done outside of these continents, although world soil maps based largely on climatic data have been constructed by the Russians, Germans, and others. Effort is being made to present a tentative soil map of the world at the Second International Soil Congress in 1930.

The gray-brownerths are low in lime and only moderate in fertility but have good structures (angular, nutlike granules ranging up to half an inch in size) and react quickly to improvements and fertilizers. They develop under forest covers—chiefly deciduous—the more open

[21] See, for example, J. A. Kerr and Others: Soil Survey of Natchitoches Parish, La., *U. S. Dept. of Agric., Field Operations of the Bur. of Soils, 1921 [23rd Rept.]*, pp. 1395–1441. Here the field party, of which the writer was a member, mapped 24 different soil series and 44 soil types in an area of 1265 square miles.

canopy, as compared with the coniferous trees of the podsols, permitting the existence of soil fauna. These organisms are instrumental in the decomposition process of the vegetable débris, which falls to the surface in fair profusion. The material does not accumulate as raw humus under normal conditions but is more or less incorporated with surface horizons and, in contrast with the podsols, is not transferred and concentrated in the subsoil. The soils will not submit to continued farming without the addition of nitrogenous matter, however, as the content of organic matter is low and soon becomes "exhausted." They also lose their structure if improperly handled.

The gray-brownerths take first rank among the humid forest soils as regards native fertility. Moderately long summers favor a more complete mineral decomposition and the release of more soluble plant food elements than is the case with the podsols. Cold winters are of considerable importance in checking the continuous all-year-round leaching, which characterizes the rederths. Under cultivation there is also less surface erosion during this season than that to which the rederths are subject. The nongrowing but open winter seasons of the latter expose the soils to severe erosion when not protected by cover crops.

The summers of the areas in which the gray-brownerths occur are generally hot; yet weather changes are frequent, and the climatic average is stimulating to man. Since the potash and phosphate, as well as the lime and nitrate content of the soils is not high, the use of fertilizers is general,[22] the forms employed varying with intensity of agriculture and economic conditions. Animal manure forms a greater proportion of this material in Europe than in America. The crop production of both regions is large and varied, as the soils are responsive to good treatment. The labor factor brings about important differences in yields and crop associations, however, since Europe is densely populated.

The principal crops are divided among grains, roots, hay crops, and specialties. A fair surplus is commonly exported, especially from America, grains and animal products supplying the bulk of the surplus goods. The European is less inclined towards commercial agriculture in staple crops than the American. He devotes himself largely to specialties—fruits, dairy products, wine, etc. The American has passed little beyond the extensive stage, however.

The production of the gray-brownerths is especially noteworthy in view of their topography. The land forms include large areas of rough, hilly country, the Appalachians and the highlands of western

[22] The poor soils of western Europe greatly stimulated experimental work in the use of fertilizers in the nineteenth century. The famous Rothamsted station of England stands among the aristocracy in this respect. For a summary account of the agricultural revolution as affected by the "discovery" of rotation and the rôle of fertilizers see C. F. Marbut: The Rise, Decline, and Revival of Malthusianism in Relation to Geography and Character of Soils, *Annals Assn. of Amer. Geogrs.*, Vol. 15, 1925, pp. 1–25.

Europe for instance. As a whole they are nevertheless noted for their well developed and progressive agriculture, although handicapped by the need of continuous fertilization.

### The Lime-Accumulating Soils

The lime-accumulating soils, the second division of the highest soil category, occur in regions of light to intermediate rainfall. The mature soils are fundamentally characterized by their calcium carbonate accumulations, the material forming whitish or grayish zones in the lower B horizons. These zones are popularly called the lime zone. Lime is usually present in some quantity throughout the entire soil mass but is highly concentrated in the lower part of the subsoil where some of it may separate as nodules, flecks, and concretions. The accumulation occurs, moreover, regardless of the character of the parent material. It is a typical soil evolution phenomenon and is not a product of geological processes except in the broader, more inclusive sense of the science.

The soils of this division vary widely in color—from the light-colored members of the desert to the black series of the well grassed plains—the colors ranging with climate and vegetative covering. From the chemical standpoint, they are relatively unleached. The soils have experienced marked changes, however, and are quite unlike their parent materials, as both physical and chemical alterations have occurred. The most striking chemical change has been indicated—the transfer and accumulation of lime in the B horizon. The important physical changes include the structural organization. There is no noteworthy tendency, however, for the B horizon to develop pronounced heavier-textured horizons than the surface zones. This latter feature seems to be normally characteristic of only mature non-lime-accumulating soils.

The soils as a class are adequately supplied with "plant foods" and rank as good fertile agricultural soils, although their production may be markedly limited by the low rainfall of their area of distribution. Three outstanding groups may be recognized—the grayerths of the deserts, the chestnuterths of the semiarid regions, and the chernozems of the transitional, subhumid rainfall belts. Significant differences include not only color but also structure, the depth of the lime zone, and other characteristics.

### The Chestnuterths

The chestnuterths include the intermediate colored group, the browns[23] to chestnut browns. These soils have developed under the

[23] The brownerths lie between the chestnuterths and the grayerths of the desert, but space precludes their description here. Their geographic relationships include both chestnuterth and grayerth features.

semiarid conditions of both middle and low latitudes. The typical vegetation is grass, the plant associations being of varied character. There is a fair to good percentage of nitrogen as the fine roots are intimately commingled with the soil mass. In view of the light rainfall the soils are unleached. They have a good percentage of all constituents necessary for high productivity.

The chestnuterths are also marked by roughly developed granulation, the soil material being organized into small clodlike structures. The upper surface horizon may be only a loose structureless dust mulch, but the understructure is coarse and cloddy. The soil is very amenable to plowing, however, the smooth and level plains, upon which it is typically developed, being ideal for machine culture.

While the climate under which these soils have developed is semiarid, the average rainfall is heavy enough to produce a natural growth suitable for grazing. Agriculture is practiced with the assistance of specialized farming methods, such as dry farming, and drought-resistant crops, like sorghum and kaffir are produced; but the dominant activity is necessarily the pastoral one. The live stock varies with latitude, pasture conditions, and other factors—sheep, cattle, goats, camels, etc. being grazed. The native vegetation, made up largely of grassland formations, furnishes good pasturage in the middle latitudes, but it is often coarse and only fair in the great grasslands of the tropics. The quality of the meat produced in the latter areas is low in grade, as even good stock is incapable of producing high-quality beef on inferior forage. Nomadism is common, and outside of the thickly settled oases the population density is low, the ratio of man to land acreage in some cases being very small. The river oases are chiefly "islands" of fresh "foreign" soil and greater water supply which have invaded the region along drainage lines.

### The Grayerths

The surfaces of desert regions are characteristically pebbly, sandy, or rocky. The pebbly areas exhibit the typical soils of the desert. The loose, shifting sand of the dunes does not constitute soil in the scientific sense. The stone deserts are completely destitute of even unconsolidated soil-forming materials except such coarse débris as is not removed by the wind.

The pebbles are highly polished and form the well known desert pavement. This horizon is thin, usually not more than an inch or two in thickness, and light in color—gray or very light brown. The underlying zones are variable. They are whitish or brownish, loose, and seemingly structureless. The soils, however, have lime zones, similar in nature and origin to those of the chestnuterths; but the position in the solum is close to the surface. The low rainfall has reduced the internal translocation processes to the minimum.

The natural vegetation is scattered, harsh, and scanty; and the animal world which depends upon it is proportionately reduced in numbers. The great bulk of the desert is empty except for the scattered pastoral nomads with flocks of sheep, goats, and camels. The animals crop the scrubby tough herbage, giving meat of low quality. Dense populations of considerable size are associated only with the fresher irrigated soils of the piedmont plains (Salt Lake Oasis) or streams, such as the Nile, which arise outside of the desert and bring water as well as younger soils to the dry wastes of sand, stone, and pebbles.

## The Chernozems

Belts of relatively intermediate climate separate the semiarid from the humid lands in both the middle and low latitudes. The natural vegetation is tall grass, which grades into short-grassed steppes on the drier margins. The soils are well known for their dark coloration—the black earths—dark brown to black in the cooler middle latitudes, with lighter colors prevailing in the tropics. In common with other soils developed under low rainfall conditions, they are both nonacid and have lime accumulating in a distinct zone in the subsoil (Fig. 3). The phosphorus and potash content is medium to high. They have excellent structure, the perfection as a group being unsurpassed. The structure particles are small in constitution—not coarse and cloddy like the chestnuterths. The chernozems include soils in the middle latitudes, moreover, with such excellent granulation that they are unequaled for ease of cultivation and plow agriculture, the soil being capable of forming a perfect tilth. Such soils occur in central Nebraska and Kansas. They may be said to "melt in one's mouth" as far as their natural cleavage is concerned.

The soils are highly fertile and show no indication of natural impoverishment. The internal drainage is excellent, but the normal soils have not experienced a marked translocation of the finer materials, such as clay, from the A to the B horizons. The latter may be slightly more compact than the upper zones, but the differences which mark the humid soils (relatively light-textured surface soils and heavy-textured subsoils) are not in evidence. In fact, chernozems constitute the ideal group from the "good soil" standpoint.

When rainfall is adequate these soils are capable of exceeding all others, with the exception of certain young black limestone and fresh, "alluvial" soils, in both crop production and ability to maintain a continuous cropping system when properly tilled and managed. The chief limiting factor is obviously precipitation, as the rainfall is low to moderate. In this sense they stand opposite the laterites. The chernozems are the "best soils" but have a poor agricultural climate; the laterites have the "best climate" as far as abundance

of rainfall and high temperatures are concerned, but they are leached and impoverished.

The dark chernozems occur in Eurasia, North America, the Argentine, and presumably Australia; the lighter-colored members in the hotter climates of the tropics and extra tropics. The tropical chernozems seem to rank agriculturally below those of the cooler climates, however, as they become soft and sticky when wet, and cracked when dry.[24]

The chernozems, like the red soils of the tropics, constitute one of the more striking soil groups of the world. Their unusual character and large development in Russia was a prime factor in prompting, during the nineteenth century, the investigations of the Russian soil scientists whose stimulating work brought about the development of modern soil science.[25] The agricultural excellence of the black earths is universally axiomatic. They embrace the great grain lands of the middle latitudes, great acreages of which are devoted to breadstuffs, especially wheat. The high nitrogen content and the excellent structure of the soil are especially well suited to the penetrating roots of the cereal crops. Population is not dense, however, since the painstaking garden agriculture of populous Eurasia has been supplanted by the use of machinery. It is probable that the soils are unexcelled in the great surplus which they contribute to international commerce.

### The Prairyerths

Between the grayish brown forest soils of the northeastern United States and the chernozems of the low-rainfall belt west of the Missouri River lies a large triangular area whose natural vegetation was the long-grass prairie. It is caught between two prongs of the gray-brownerths, one of which extends northwestward into Minnesota while the other projects southwestward into the Ozarks. All known natural causes seem to indicate that this area, too, should be forest; but for some unknown or incompletely demonstrated reason it is grassland.

The environmental conditions of this area do not seem to be significantly unlike those of the gray-brownerths region, but the soils are very different from those which the environment would lead one to expect. They are very dark brown to black in color and are somewhat acid in reaction, while the humid forest soils are brown in color and very acid in reaction. The soils, at least as regards their more important characteristics, show closer resemblance to the chernozems. The coloration is similar, the profuse roots of the long prairie grasses having

[24] Shantz and Marbut, *op. cit.*, pp. 165–166.

[25] For detailed descriptions of several soil series of the American chernozems, or black earths, see the Soil Survey Report of Adams County, Nebraska, by F. A. Hayes, the authority on the central black earths of the United States, or the writer's report on Nuckolls County (both in publication).

been thoroughly commingled with the upper soil mass in the process of soil evolution. The soil material, moreover, is friable and easily worked, as the structure is finely granular, not nutlike as in the forest. The subsoil is often compacted, but it is usually not markedly heavier-textured than the surface horizons. The chief exception, in addition to acid reaction, is the lack of a zone of lime accumulation at maturity. The prairyerths, therefore, belong to the non-lime-accumulating group, although they have important features in common with the lime-accumulating soils. Certain immature soils of the region (northern Iowa) are still possessed of lime inherited from geological processes, but this lime is being gradually lost through the drainage waters and is not accumulating in the lower subsoil. It does not appear, however, that the mature soils are as acid or as low as the forest soils in either potash or phosphates, but they are benefited by the application of lime and manure in moderate quantities.

These soils, like the chernozems, are developed chiefly on smooth-plains topography. The rainfall, however, is from 50 to 100 per cent higher, and the crop production is heavy and usually certain. Their area of distribution is roughly coincident with the western two-thirds of the Corn Belt. Smaller bodies exist farther west; and similar soils are believed to occur elsewhere, but their existence is not yet fully verified. With only a moderate population density, the known prairyerths have had an enormous surplus and have poured vast quantities of meat and grain on the international markets in addition to feeding a large part of the population of the United States. These dark-colored soils and the black chernozems together probably contribute more foodstuffs to world commerce than any other equal area of soils. They are extremely productive. From the standpoint of agricultural economics it is unfortunate that the chernozems and prairyerths have not a larger area of distribution. They are the prize soils of the world.

# A MAP OF THE WORLD'S LAW

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[With separate map, Pl. II, facing p. 120]

A MAP of the world's law! Has any one ever seen such a map? There have been world maps of rainfall and of temperature, of cereal crops and of timber belts, of population and of illiteracy, of race stocks and of religious creeds, and of all the fundamental geologic, zoölogic, economic, and social facts. But of law? We do not know of any map that has hitherto seen the light in print.

But, a map of the world's *laws?* There would be millions of laws; no map could record them. Nevertheless, all these laws fall into *systems* of law, and these systems of law are limited in number and can be mapped. Every nation, every locality, every tribe, throughout the earth's surface has of course had its customary laws, since the beginning of social history. But in only a few instances have these local customs developed into systems. A system of law is a body of rules covering the elemental institutions of social life, developed by the thought of a professional class, and connected into a sort of corporeal unity by a certain logical and social consistency. These systems, when once formed, have held together for centuries and have often spread from their native area to include widely unrelated peoples. Today, more than nine-tenths of the world's population live under the influence, direct or indirect, of less than a dozen systems of law.

Originally, some sixteen systems can be traced in the world's history; they are sketched in my book "A Panorama of the World's Legal Systems."[1] But of these sixteen some eight have disappeared as such—the Egyptian, Mesopotamian, Hebrew, Greek, Roman, Celtic, Maritime, and Canon systems. There remain, represented on the world's surface today, either pure or in combination, the following: Chinese, Hindu, Japanese, Germanic, Slavic, Mohammedan, Romanesque, Anglican. Besides, there must be added, for notation on a map, Tribal Custom, for areas where no system had developed.

## Geography and the Law

But before explaining the map, a few words should be said as to the influence of geography in the evolution of law in the earth's peoples.

[1] John H. Wigmore: A Panorama of the World's Legal Systems, 3 vols., St. Paul, Minn., 1928.

Nothing comprehensive yet has been attempted on this subject,[2] and at this time only a few suggestions of its possibilities will be made.

The influence of geography has operated in two ways—immediately, through natural features, and mediately, through race and race traits. The latter form—mediately, through race—has been vital. All except three of the principal legal systems have originated in particular race stocks and have usually taken on their distinctive traits before the race stock had been diluted or the system transplanted. The three exceptions—Maritime, Papal, and Romanesque law—have arisen independently of race. The first had a geographical origin, the second a religious, and the third an intellectual. But the study of this indirect race influence would lead us too far afield.

Direct geographical influence is of course bound to be elusive: it is seldom easy to disentangle it, as a cause, from the other numerous circumstances attending the growth of a legal system. One or two instances must here suffice.

Terrestrial distribution, that is land versus water, led to the growth of a maritime legal system distinct from any racial or national territorial systems. But coast line seems, oddly enough, to have had little direct influence; for the Romans of Italy, with an extensive coast line, were weak in maritime law, borrowing theirs from the island of Rhodes; and the English similarly borrowed theirs from France.

Contiguity has had much to do with the growth of some legal systems, by producing imitation or peaceful penetration among neighboring peoples. For example, the Mesopotamian system (of Babylonia and Assyria) seems to have been assimilated in adjacent regions; the early native Egyptian system spread westward; and the Germanic system penetrated the adjacent Slavic regions.

Mohammedan law is in its origin a law of the desert. The close relation between the region of Mohammedan law and the great continuous area of scant rainfall (below 10 inches) and of interior-basin drainage in the Old World is striking.[3] At the same time within the system there are interesting differences for the desert proper and the oases: as between Bedouin Law and the Egyptian Penal Code.[4] On the other hand, climate seems to have had no influence on the Buddhist religious legal system, which, originating in the warm plains of India, spread northwards into the icy plateau of Tibet and the dreary steppes of Mongolia.

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[2] In Kocourek and Wigmore's Evolution of Law Series (1917), a compilation from the world's legal literature, Vol. 3, "Factors of Legal Evolution," contains two suggestive chapters, viz. Mr. H. J. Randall's "Law and Geography," and Miss Ellen Semple's "Influences of Geographic Environment on Law, State, and Society." Of concrete treatment an example will be found in Mr. Henry A. Dubbs's "The Unfolding of Law in the Mountain Region," *Colorado Mag.*, Vol. 3, 1926, pp. 113–132.

[3] See Pl. I, B and C, in Isaiah Bowman: The Mohammedan World, *Geogr. Rev.*, Vol. 14, 1924, pp. 62–74.

[4] See, for instance, Austin Kennett: Bedouin Justice: Laws and Customs Among the Egyptian Bedouin, Cambridge, 1925.

The above instances refer to systems as a whole: when we come to particular rules of law within a system, causative influences are more readily detected. In the *form* of law, the records embodying it vary directly with the materials available in a particular region: the Egyptian papyrus, the Babylonian baked clay tablets, early Arabian records on camel bones are obvious examples. The *place* of doing justice is often suggestive. Among the Mohammedan peoples justice was dispensed at the door of the tent, at the shady gate of the city or the temple, or within the mosque. So too with modes of punishment. In India execution by the trampling of a trained elephant was observed as late as 1880. In Central Africa the guilty person might be bound to an ant hill, to be devoured to the bone.

The incidents of landownership—the various petty dues, fees, and rights—naturally varied with the environment. In India landownership carried the right of fastening elephants and buffaloes for pasture; in England the owner was entitled to "wood bote," a service of wood cutting; in Mesopotamia and Egypt the irrigation customs were vital, as indeed irrigation customs are in arid lands the world over, today as in the past. Thus the extant deeds of land from the various systems contain clauses characteristic of the variant regions.

So, too, bodies of rules of law will be found in one system which do not appear at all in systems located among other natural features; for example, rules for dikes in Holland, for canals in Spanish Granada, where a "water court" exists even now, for mountain pasture in Switzerland and Norway, for cattle in Ireland.

In family law certain rules were widely different, and the differing social conditions producing them had no doubt some geographical basis. The detailed causes here would be very difficult to disentangle. One of the largest questions would be how far polygamy, as a regular order of life, was influenced by tropical conditions. Another question would be how far geographical conditions controlled the rules of inheritance. As to this, it is certain the English rule of male primogeniture for land, which drove away the vigorous younger sons to seek their fortune elsewhere, was later a prime cause in the growth of England's colonial empire, and thus of the world-wide spread of the Anglican legal system. But whether that rule itself—the rule of male primogeniture—was due to the unconscious influence of England's narrow island limits, inculcating the indivisibility of estates, and thus to geographical facts, is a conundrum; and only a careful analysis of comparative history and other facts would reveal the answer.

When we come to specific rules of commercial law, it becomes even harder to detect a geographical influence. For example, the much mooted question whether in a sale of goods the title to the goods passes to the vendee by the mere agreement to sell or not until manual delivery of the goods—if we find that the one version was adopted

among the Germanics of Europe and the other was adopted among the Mohammedans of the north African deserts and mountains, are we to look for some climatic or other geographical fact as the explanatory one?

The foregoing instances will at least suggest not only the rich possibilities of the subject but also the complexity of the task of tracing the influence of geography upon law.

## The Map: Classification of Systems

On the map, Plate II, systems alone can be separately shown, i. e. the few developed bodies of law, not the innumerable unorganized groups of tribal custom. But all systems now in existence are more or less mixed in origin and history, and the various shades of these mixtures are too numerous to be represented. Hence only the system representing the present dominant character or characters of the law in a given nation or area can be shown.

Nevertheless, some mixtures cannot be ignored. In certain areas, to show a single unmixed system would be misleading and would be valueless for the purpose of analyzing tendencies. Therefore at least four distinctions in types of mixtures seem necessary as well as feasible to represent on the map. These four types are as follows:

1. *Pure* systems, that is as in England or France.

2. *National blends*, that is where a people having a native system has adopted in part an alien system by recasting its native system in alien categories or otherwise, thus making a single blended system under native sovereignty, as in Japan.

3. *Colonial composites*, that is where an alien power, holding a colony or protectorate or mandate, has imposed its own political or public law but continues to preserve and enforce the native system for private law, in part or in whole, as in Algeria.

4. *Colonial duplex composites*, that is where an alien power has imposed its own system but enforces two or more native systems for separate classes of natives. India is the only notable example of this type.

Extraterritoriality is not here shown, that is where a native sovereignty enforces foreign law for the alien residents as a separate class of persons, either in consular courts or in mixed courts; this form of jurisdiction does not add to the types of systems, though it may affect large numbers of the population.

On the above four types further comments must be made:

*Pure systems.* Of the sixteen systems mentioned above only eight can be recognized to be surviving as such in today's world, viz. Anglican, Chinese, Germanic, Hindu, Japanese, Mohammedan, Romanesque, Slavic.

Of these eight only four are now found anywhere as pure systems, viz. Anglican, Hindu, Mohammedan, Romanesque; the others appear only in blends or composites.

*Blends.* The distinction between a blend and a composite is this: in a blend various institutions from two systems are fused into a single system under native sovereignty, applicable to all persons in the jurisdiction (except extraterritorial exemptions); but in a composite the two systems remain separate, each being applicable to a different group of persons. Thus there might conceivably be a *national* composite: there is, in fact, in Egypt and elsewhere, and there was in imperial Russia, a national composite, though for groups of persons too small to be here recognized. But on this map the blends are only national, that is under native sovereignty; and the composites are only colonial, that is under alien sovereignty.

One particular blend calls for special note, viz. the Russian Soviet Federation. Here the foundation is still more or less the historical Romanized Slavic blend, nominally displaced by the Communist system; but the Communist institutions are formulated in Romanesque categories, and at the present time it seems best to class the system as a blend, not a new independent system.

Blends, of course, differ in the degree of actual application of the borrowed system as law. For example, in Japan and Siam the blend has long been thorough; in China it has made substantial start; in Turkey it is as yet beginning; in Persia it is in embryo. No attempt to show such differences is made on this map. Nor can the map attempt to show differences in the various parts chosen from the two systems for blending. For example, in Scotland and in the South African Republic the elements taken from the Romanesque system would be very different from the Romanesque elements taken by Japan, by China, by Persia, by Siam.

Blends are of course open to difference of opinion in respect to the *quantity* of a blended element that entitles it to recognition for particular nations. For example, Scotland and the South African Republic are commonly classed under the Romanesque system; yet the Anglican element is too large to be ignored, and therefore both those countries are shown on the map as blends. The Scandinavian countries are also commonly classed as Romanesque; yet the Germanic system (obsolete everywhere in its pure form) is there so largely preserved that it cannot justly be ignored, and all of those countries are therefore shown as blends. For these and other countries the map has chosen solutions which are no doubt open to difference of opinion.

*Composites.* In a composite system the number of native systems (that is, of "personal" law) that might be actually enforced by an alien sovereignty is of course theoretically large. In some countries, no doubt, it is at least plural. But only the one major native system is

recognized on this map; that is, the one in force among the large mass of the population. The only composite country for which two native systems are shown on the map is India, where Hindu law and Mohammedan law must each be recognized.

Where no organized system is found, but only *local tribal customs*, this infinitely variegated type is represented on the map by a single symbol. It always appears as a composite, of course, because the whole terrestrial surface is now nominally under the sovereignty of one or another national power; and thus the areas in which local tribal custom still obtains are usually under one or another alien power, either as colonies, protectorates, or mandates. Local tribal custom is of course recognized, or actually in force, in many areas of Asia and of Africa too small to be designated on the map. Some of them, moreover, are in strictness national composites, not colonial composites.

In the lesser known or more recently dominated areas of Africa and Asia, there are many border regions where the allotment of systems must of course be tentative only. For example, in Africa the region of Mohammedan law (as a composite element) shades off gradually into the region of tribal custom. So, too, in northwestern and north-central Asia, the areas of tribal custom, as contrasted with the surrounding Chinese, Hindu, Mohammedan, and Soviet systems, leave many doubtful border lines. The map here attempts to show no more than broad tendencies.

As to the kind of law—public law, etc.—that is imposed by the alien political power in colonial composite systems, this differs, of course, under different powers. Alien taxation law and police law are always found; also more or less penal law and often judiciary organization. Civil procedure is sometimes included, as in India; sometimes not, as in Morocco. No attempt is made to represent these variations on the map.

## Symbols Used on the Map

The representation of these types of systems on a map can best be made by using colors to indicate the systems, and numerals to identify the regions where the systems obtain.

The four *types* of systems—pure, blend, composite, and duplex composite—are thus distinguished:

1. Pure system = single color, e. g. England, in red (Anglican).

2. Blend = the ground color of the basic system crossed by a bar in color of the blended system, e. g. Turkish Republic, in dark green (Mohammedan) crossed by a bar in blue (Romanesque).

3. Composite = the ground color of the native system sur-

rounded by a marginal boundary in color of the alien system, e. g. Algeria and adjacent French dependencies in dark green (Mohammedan) surrounded by a boundary in blue (Romanesque).

4. Duplex composite = same as in the preceding, but with two ground colors in alternate blocks, e. g. India, in blocks of the Mohammedan and Hindu colors.

Regions—nations, colonies, protectorates, etc.—are indicated by numerical figures. The terrestrial surface is divided into five major divisions, America, Europe, Africa, Asia, Australasia and Oceania. Within each division the several countries, etc., after being arranged alphabetically, are numbered serially, and this number is placed also on the map at the proper location. Countries and possessions not large enough for map marks, or not important enough for distinction from adjacent areas, have been ignored; thus for instance Andorra, whose legal system is *sui generis*. A key below the map lists the region by numbers, and the systems of law by initial letters.

## Ascription of Systems to Particular Regions

There is of course some room for difference of opinion in the ascription of systems to particular regions, even of those systems that have long been well known. For regions not yet fully described in authentic legal chronicles, there is even more room for controversy by those who have special knowledge of particular areas. The allotment shown on the map represents the author's opinion—tentative in many instances—formed in the light of available information.

# CHANGES IN THE OCEANIC CIRCULATION AND THEIR CLIMATIC CONSEQUENCES

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IN the last decade of the nineteenth century, between 1892 and 1897, there occurred an enormous outburst of ice from the Antarctic which filled the Southern Ocean with ice floes and icebergs to such an extent that traffic between South America, Africa, and Australia had to seek a more northerly track. This outburst had far-reaching climatic repercussions. The monsoon regimen of the Indian Ocean was profoundly disturbed. In India 1893 and 1894 were years of excessive rainfall; then, in 1896 and 1899, came years of drought followed by widespread famine. The area in which crops failed more or less completely was about 256,000 square miles in extent in 1896 and 500,000 square miles in 1899. In 1899–1900 upwards of 6,500,000 people were on famine relief for several months. The loss of cattle was great, running into many millions: in some districts 90 to 95 per cent of the stock died. Australia also suffered. In New South Wales and Queensland almost continuous drought prevailed from 1896 to 1902. It is estimated that over 50,000,000 sheep, valued at £12,500,000, were lost during these seven years.[1]

Reports of ice dangerous to navigation in the Southern Ocean began to appear again in 1922. We do not know which part of the Antarctic shelf was the original seat of this outburst, but it seems likely that it came from the Pacific and Atlantic rather than from the Indian side since its aftereffect has been a disturbance of the Humboldt and the Benguella currents. On the former current Mr. R. C. Murphy has published an elaborate and comprehensive study.[2] He shows that the Humboldt Current must have been deflected westwards early in 1925, allowing the warm coastal waters from the Bay of Panama, i.e. the countercurrent El Niño, to penetrate southwards along the coast and thus cause an abnormal rainfall along the arid coasts of Ecuador, Peru, and Chile. This phenomenon though rare is not unprecedented; it appears to repeat itself periodically at intervals of about 34 years, which reminds one of the Brückner cycle.

[1] Sir John Eliot: A Preliminary Investigation of the More Important Features of the Meteorology of Southern Asia, the Indian Ocean and Neighboring Countries During the Period 1892–1902, *Indian Meteorol. Memoirs*, Vol. 15, Part I, 1903, pp. 185–307.

[2] R. C. Murphy: Oceanic and Climatic Phenomena Along the West Coast of South America During 1925, *Geogr. Rev.*, Vol. 16, 1926, pp. 26–54.

Simultaneously with the westward deviation of the Humboldt Current there took place a corresponding deviation of the Benguella Current, permitting the warm waters of the Guinea Current to expand southward with a similar effect on the climate of the African sub-continent—torrential rains and inundations. From the British Meteorological Office I have received records of the extraordinary rainfall in Nyasaland and Rhodesia.[3] In the former, the rainfall for the early months of 1925 was the greatest ever experienced within European knowledge of this part of the tropics, and it resulted in excessive damage to crops and communications both here and in Rhodesia and also in parts of South Africa. At Zomba 367 millimeters of rain fell in March, whereas the average is 224 millimeters. In Salisbury the rainfall was 304 millimeters against an average of 214 millimeters. The rainfall of 1926 in Zomba was a repetition of that in 1925 or even worse, being about three times the normal fall. At Mossamedes (lat. 15° 11′), which is perhaps the most arid station on the coast of the African sub-continent, the rainfall in February, 1925, was more than double the highest record ever obtained in that month. Heavy rains are also reported for Namaqualand[4] and Ngamiland.[5]

Outbursts of polar ice also occur in the Arctic. The outburst of 1903 is still fresh in the memory of the Scandinavian countries because it was followed by a general failure of cod, herring, and other fish along the coast from Finmarken and Lofoten to the Skagerrak and Kattegat. The greater part of the Barents Sea was covered with pack ice up to May, the ice border approaching closer to the Murman and Finmarken coasts than ever before. Herds of arctic seals visited these coasts, and some species of the arctic whitefish extended their migrations to the Christiania Fiord and even entered into the Baltic.

A closer inspection of the changes in oceanic circulation with the attendant climatic changes, of which the above are recent examples, suggests a periodicity underlying all these seemingly irregular phenomena. Upon this problem I have been engaged for many years. The first aspect of it to be considered is the process of ice melting and its relation to the general circulation of the ocean waters.

## The Ice-Melting Process and Its Dynamics

I began to study this subject 45 years ago when working up the hydrographic observations of Nordenskiöld's *Vega* Expedition on

[3] By courtesy of its Director and staff (Dr. C. E. P. Brooks and Dr. J. Glasspoole).

[4] "The Brak River, during the heavy rains of July 1925, carried water to the Orange River for the first time within the memory of the Hottentots" (W. A. Humphreys: The Changed Conditions of Namaqualand, *Trans. Royal Soc. of South Africa*, Vol. 16, 1927, pp. 219–224).

[5] Bechuanaland Protectorate, *Ann. Colonial Rept.* for 1926–27, London, 1928.

which he accomplished the first circumnavigation of Eurasia (1876–1878). I observed then that in every deep sounding made by Nordenskiöld in the ice-filled Kara Sea and the Arctic Ocean there was always found warm water—water, that is, of a temperature above 0° C.—under the ice wherever the depth was great enough to allow an undercurrent to enter. It was evident that this warm and salt water must have been brought to these remote eastern parts of the North Atlantic by some ramification of the great artery of warm water of that ocean usually called the "Gulf Stream," which thus must exist as an undercurrent long after it has left the surface. For physical reasons I concluded that ice that melts in salt water attracts to the place warm water from the neighborhood. But I could not be sure that this was the only force acting, as the presence of the warm water under the ice floes of the Siberian Sea could also be explained in another manner, viz.: by the deviating influence of the earth's rotation which compels currents from the south to take an easterly direction in the northern hemisphere.

Nordenskiöld's next expedition brought results that settled the question. This time (1883) he went westward to Greenland in search of the site of the old settlements of Norsemen in the Viking age. When his ship crossed the Polar Current to the east coast of Greenland, which had been inaccessible since the beginning of the fifteenth century on account of the polar ice drift, and reached the Gunbjörskjär of the Sagas (Angmagssalik) in latitude 67° the hydrographer, Axel Hamberg, had an opportunity to make a complete series of deep soundings across the Polar Current. The result was as follows:

On the continental shelf off Greenland the Polar Current carried ice and ice-cold water from the surface to the bottom at 150–200 meters, but just outside the shelf there was found an intermediate layer of warm and salt water between the Polar Current and the undermost water layer which was cooled to the freezing point of ice in sea water (−1° to −1.9° C.). This intermediate layer was interpreted as an indraft from the eastern side of the Atlantic which, in spite of the deviating influence of the earth's rotation, had been deflected westward by a stronger and hitherto unknown force which must be an effect of the ice-melting process.

These observations, made 45 years ago and confirmed by a number of similar experiences of recent date in the Arctic and Antarctic seas, bear out the general rule that, without exceptions, *There exists in every ice-filled region of the ocean an indraft of warmer and salter water as an undercurrent from lower latitudes.*[6]

I have demonstrated the process of ice melting and the currents to which it gives rise in the laboratory. My first attempt to solve

[6] Provided that the depth of the sea is sufficient to permit an undercurrent to enter under the ice and ice-cold surface water.

this problem from the dynamic point of view was published in *Petermanns Mitteilungen*.[1] The operation of the process in the northern Atlantic may be briefly summarized.

The northern part of the Atlantic, i.e. the Norwegian Sea and the Polar Basin, is separated from the main part of the ocean by a submarine ridge, extending between Greenland, Iceland, the Faeroes, and Shetland, which impedes the southward movement of the polar ice and divides the Polar Current into two branches. There is a great accumulation of ice in spring north of Denmark Sound between Greenland, Iceland, and Jan Mayen. During the summer this is considerably reduced (see Fig. 1). A part has drifted away with the Polar Current southwards through Denmark Strait. Another part has melted under the influence of the wind and the season. A third part has been melted by the warm undercurrent, a branch of the Gulf Stream which enters the Norwegian Sea over the submarine ridge. The diluted water from the melting ice flows as a surface current, the so-called East Iceland Polar Current, in a southeasterly direction between Iceland and Jan Mayen. The warm Atlantic water which has given up the heat necessary for the melting of the ice sinks down. It has become a little less salt from its contact with the ice, but it is nevertheless denser than before on account of its reduced temperature. It fills the deep basin of the Norwegian Sea to the level of the ridge, over the lowest parts of which, e.g. the Wyville Thomson Bank between the Shetlands and the Faeroes, it escapes as a submarine waterfall into the deep basin of the eastern Atlantic. The large scale on which the melting process goes on in the Norwegian Sea accounts for the fact that this sea contains the coldest (down to −1.93° C.) and densest (up to 1.028) sea water on the globe.

FIG. 1—The state of the ice in the seas east of Greenland and Spitsbergen and in Davis Strait, 1896. The dashed line shows limits of the ice pack in May; the dotted line, limits in July. (Based on charts of the Yearbook of the Danish Meteorological Institute for 1896.)

From the deep soundings of the Danish *Ingolf* Expedition in the year 1896 we infer that there exist in this part of the sea three different

[1] Otto Pettersson: Die Wasserzirkulation im Nordatlantischen Ozean, *Petermanns Mitt.*, Vol. 46, 1900, pp. 61–65 and 81–92. See also *idem:* On the Influence of Ice-Melting upon Oceanic Circulation, *Geogr. Journ.*, Vol. 24, 1904, pp. 285–333, and Vol. 30, 1907, pp. 273–303.

water layers. The uppermost belongs to the Polar Current and carries ice-cold diluted sea water of a mean density of 1.0265. It consists of a mixture of $\frac{1}{18}$ ice water of −1.6° C. with a density of 1.00017 and $\frac{17}{18}$ Atlantic water. The second layer consists of Atlantic water with a temperature above zero and 35.06 per mille salinity. Under this warm and salt Atlantic water was found the ice-cold bottom water of the Norwegian Sea of −0.8° or −0.9° C., which consists of Atlantic water that has been cooled by contact with the ice and a little diluted so that its salinity has been reduced to about 34.9 per mille—the characteristic salinity of Arctic water.

The *Ingolf* soundings also supply data for an estimation of the magnitude of the energy set free by the ice-melting process in nature. From elementary thermodynamic principles I calculated the energy thus developed in summer between Iceland and Jan Mayen at some 388,000 horse power. This is the energy that drives the East Iceland Polar Current, which cannot be considered as a wind current since it flows in a contrary direction to the prevailing winds.

## Centers of Action

Mathematically it can be shown that the ice-melting process is of such considerable importance that we must ascribe the vertical circulation in the ocean mainly to this cause. The regions where ice melting on a grand scale goes on may be regarded as real centers of action—this expression, introduced by Teisserenc de Bort in his famous treatises on the dynamics of the atmosphere, being used to denote correspondingly the seats of origin of the current system in the ocean.

Two such centers of paramount interest are situated in the northern hemisphere: in the Norwegian Sea and off the Newfoundland Banks where the ice drift from the Polar Basin and Baffin Bay encounters the warm waters of the united Florida and Antilles currents. In the southern hemisphere also we have two centers: first, the limit of the drift of Antarctic ice floes between latitudes 40° and 50° S.; and, secondly, the border of the Antarctic ice barrier in latitude 70° to 80° where the icebergs of the southern ocean originate.

Our knowledge of the centers of action is due to recent German investigations of which a representation is given in the following section of the Atlantic Ocean along the 30th meridian W., designed by the leaders of the *Meteor* expedition, Merz and Wüst.[8]

The salient features of this section are:

1. The undercurrent of warm and salt water which in depths between 1200 and 3500 meters penetrates the South Atlantic Ocean

[8] Die Deutsche Atlantische Expedition auf dem Vermessungs- und Forschungsschiff "Meteor," *Zeitschr. Gesell. für Erdkunde zu Berlin*, 1926, pp. 1–77 and 209–274.

from the Sargasso Sea to the Antarctic continental shelf and by contact with the Antarctic ice barrier and ice floes maintains a circulation of the bottom water in the Atlantic Ocean.

2. The undercurrent of cold water from the border of the Antarctic ice drift in latitude 40°–50° S. to about latitude 10° N. at a depth of 400 to 1000 meters.

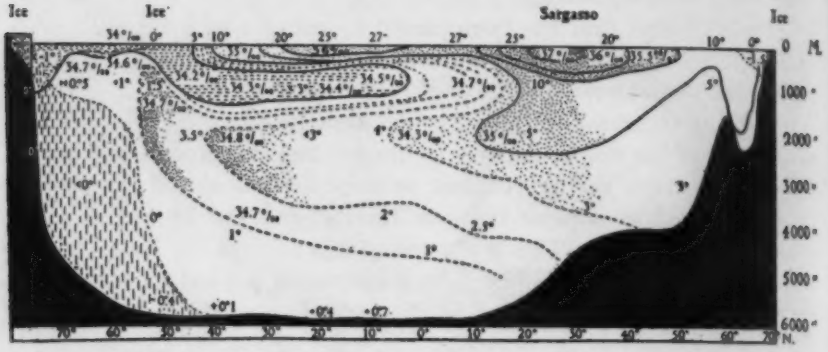


FIG. 2—Longitudinal section of the Atlantic Ocean through longitude 30° W. (After Merz and Wüst.)

## THERMODYNAMICS OF THE OCEANIC AND ATMOSPHERIC CIRCULATION

The explanation of the causes of oceanic circulation given above is new and has not been generally adopted by hydrographers, who adhere to the theory propounded fifty years ago by the German physicist Zöppritz that oceanic circulation is caused by the winds.[9] The *vis motrix* of the current system of the sea thus would be a secondary effect borrowed from the atmospheric circulation. It is easy to understand how this theory should become accepted, since experience shows that the great surface currents evidently coincide with and are ruled in their direction (to a certain extent and a certain depth) by the prevailing wind system of the atmosphere (the trade winds, monsoons, etc.). But as an explanation of the oceanic circulation as a whole it is utterly insufficient.

If we abandon the theory of Zöppritz, long and resolutely defended by Krümmel and other authorities, and consider the movements in the sea as mainly caused by direct transformation of radiant heat from the sun imparted to the water in lower latitudes (the tropical regions of the ocean, such as the Gulf of Mexico, the Sargasso Sea, etc.), and transported with the warm surface currents, the Gulf Stream, the Brazilian Current, the Agulhas Current, etc., to the Arctic and Antarctic "centers" mentioned in the foregoing, where

[9] This hypothesis is of ancient date. It was developed mathematically into a physical theory by Zöppritz.

there takes place a transformation of the potential energy stored up in the system ice and salt water into kinetic energy, i.e. into acceleration of the current system raised by the ice melting, we infer from Carnot's principle that only a relatively small part of the heat stored up in the water is transformed into kinetic energy. According to this principle the condition for a continued transformation of caloric energy into work is that there shall be a *chute de chaleur*, i.e. a transit of heat from one center of higher temperature, $T_1$ (absolute), to another of lower temperature, $T_2$, and that the transformable part of the heat absorbed at $T_1$ and given off at $T_2$ is $(T_1-T_2)/T_1$.

It has been shown in the foregoing that the principal centers where the heat imparted to the sea water in tropical latitudes is given off are situated in Arctic and Antarctic regions of the ocean. In the Atlantic the principal center of absorption of heat is the Sargasso Sea, from which warm currents and undercurrents are sent out to both hemispheres—the Gulf Stream to the northern hemisphere and the great undercurrent of warm water between 1200 and 3000 meters deep (see the diagram of Merz and Wüst, Fig. 2) to the South Atlantic and Antarctic.

Although that part of the radiant heat from the sun absorbed in the sea water which can be transformed into kinetic energy is relatively little and never exceeds one-tenth of the whole, it represents a considerable amount of work measured in horse power available for the acceleration and maintenance of the oceanic circulation.

Another part of the absorbed heat is given up to the air during the long transport from the tropical to the polar regions of the ocean and in the last instance is lost by radiation to space.

The amount of heat given up to the air—which with rare exceptions is always colder than the ocean—serves to maintain a similar thermodynamic cycle in the atmosphere consisting in the transformation of heat by evaporation of aqueous vapor which condenses to rain, fog, and snow. The thermodynamic cycle of the water in the atmosphere differs from that in the hydrosphere in that it is shorter, the condensation of the vapor taking place wherever the moist air rises and expands on encountering cold currents of air or mountains, while the solar heat stored up in sea water ordinarily first meets its transformation after a transit of some thousand miles to the ice-filled parts of the ocean.[10] The heat which the warm water loses by evaporation during transport is used in the atmospheric cycle to generate

[10] Some months ago two French physicists proposed to use the thermodynamic cycle of transformation of solar heat in sea water for economic purposes by the artificial shortening of its circuit. Hydrographic soundings have shown that 600 meters below the surface of the Sargasso Sea, which has a temperature up to 28° C., there exists a cold-water layer of only 6° C. From a ship anchored in the Sargasso Sea they proposed to establish a more direct communication between the warm and the cold water layers than that which exists in nature by means of a tube which should bring up cold water of 6° that would serve to condense the vapor generated *in vacuo* from surface water of 28° in a boiler.

atmospheric disturbances which, as cyclones, rise and take their pathway over the North Atlantic following the trend of the westerly winds.

## The Changes and Their Causation

We have found that the distribution of solar energy on earth—as well as its storage and transformation into work—is ruled by two thermodynamic cycles, one belonging to the hydrosphere, the other to the atmosphere.

In both cases the greater part of the heat absorbed at the higher temperature, $T_1$, is not transformed into work but is given up to the sea or the air in higher latitudes at a lower temperature, $T_2$. In the ocean a great part of this energy is consumed as latent heat in the melting of ice. In the atmospheric cycle only a minor part is restored to the air by the condensation of aqueous vapor as rain and snow upon the mountains of the continents, which act as condensers upon the humidity of the air just as the ice in the polar seas attracts the warm water of the ocean.

This indraft of warm air from the sea saturated with humidity sweeps over the continent of Europe in winter as a thin sheet of warm clouds, in most cases remnants of cyclones generated over the ocean which have lost their contact with that source of humidity. The climate of northern Europe largely depends upon this supply of heat and humidity from the ocean which passes overhead at an average height of 800 to 1800 meters, recorded as "inversions of the air temperature" in the registers of the meteorological stations at Lindenberg, Breslau, Petrograd, and elsewhere.

It is evident that every change which occurs in the régime of the oceanic circulation of the North Atlantic influences the climate of Europe. The same is the case—perhaps in a still higher degree—with the climate of the continents bordering on the South Atlantic, the Indian, and the Pacific oceans, which depends on the development of the current system of the Antarctic Ocean and in the last instance on the ice melting and the cold water generated by that process. At the beginning of this paper I gave instances of some exceptional conditions. I now pass to the question of the periodicity of such conditions. This I have tried to trace to planetary influence, i.e. to changes in the tidal force caused by the position of the earth relatively to the sun and the moon.

## Causation of Periodicity

In discussions of tidal phenomena the waters of the ocean have hitherto been treated as a physically homogeneous medium in which the movement of the deep water under the influence of external forces must be of the same order with regard to time and space as that of

the surface water. This is not so. The water of the ocean consists of different and well-defined layers with regard to temperature, salinity, and density which can move independently of one another hampered only by the drag or friction exerted by one layer upon another. This differentiation of sea waters is nowhere more pronounced than in the Scandinavian seas, where water layers from widely different parts of the Atlantic are found superposed upon one another with their limits so well marked that by analysis and by recording instruments their surfaces of contact can be located within a few decimeters.[11]

These boundary surfaces are liable to great changes of level which appear as huge submarine waves showing the periodicities of the parallactic tidal force. Not only the monthly and half-monthly but also the longer periods, annual, etc., appear well marked in the records kept during a series of years at Bornö, the Swedish hydrographical station in Gullmars Fjord. In ice-filled parts of the ocean they must exert an influence on the ice-melting process because they bring the ice floes and icebergs in contact with the warm and salt water below. Under ordinary circumstances the polar ice on the continental shelf of Greenland and of the Antarctic continent floats in cold diluted sea water in which the ice melts slowly, but when the submarine waves of the warm and salt deep water with enormous amplitudes—hundreds of meters and more—impinge upon the shelf at the spring tide of the parallactic tide, ice melting sets in on a grand scale. Even the Antarctic ice barrier, of which at least the outer part is in a floating condition, bursts and sends out icebergs and floes which reach farther northwards than usual and carry with them cold Antarctic water into the Indian, Atlantic, and Pacific oceans. Such catastrophes occur when the phases of the synodic, tropic, anomalistic, and draconitic periods of the moon coincide at the constellations of the perihelion apside of the moon's orbit (nearly 9 years); the saros, or coincidence of the synodic, draconitic, and anomalistic months (nearly 18 years); and multiples of the saros as 36 years (the so-called "Brückner period"). That outbursts do not occur more regularly, or in one and the same ocean or part of the ocean[12] we must ascribe to the fact that the epochs of the tropical month do not as a rule coincide with those of the others. When that happens, i.e. at the period of the perihelion node apside (about 1850 years), the disturbance caused by the polar currents becomes catastrophic, as in the fourth and fifth century before Christ, that is at the end of the Bronze

[11] I have treated this phenomenon in a number of papers in several journals and in the *Svenska Hydrografisk-Biologiska Kommissionens Skrifter*, Nos. 1–7.

[12] The "saros" of the Chaldeans is usually regarded as an eclipse period without reference to its influence on the tidal force. Just as the optical effect of the constellation that brings an eclipse is not repeated after a saros on the same longitude and at the same hour with regard to the track of the sun's or the earth's shadow, its physical effect and aftereffects which will last for years do not fall on the same ocean or in the same hemisphere.

Age, or in the fourteenth and fifteenth century of our era when Greenland was blockaded by the polar ice drift and became inaccessible and uninhabitable to the Norsemen who had settled there 500 years before in the Viking Age.

The coincidence of outbursts of Arctic and Antarctic ice with such constellations is remarkable. In the perihelion apside of 1903 the position of the moon's orbit was analogous but not the same as in 1894, and there occurred the remarkable outburst of Arctic ice that so disastrously affected our northern fisheries. Nine years afterwards, in 1912, the perihelion apside was coincident with the last great ice year of the Labrador Current memorable for the disaster of the *Titanic*.

All these constellations are of the type which have been denoted as perihelion apside which brings a secondary maximum of the tide-generating force and, if we may judge from our experience of all known cases, outbursts of ice from the polar seas. The question of what happens at the important epochs of absolute maxima of the tidal force ruled by the constellation perihelion node apside, such as occurred about 500 B. C. and 1434 A. D. I have discussed in a paper, "Climatic Variations in Historic and Prehistoric Time."[13]

## The Last Outburst of Antarctic Ice

I will now return for a moment to what occurred in the third decade of this century inaugurated by the constellation of the perihelion apside of 1921. In his account of the deviation of the Humboldt Current in 1925 Mr. Murphy quotes Dr. H. H. Clayton on changes in solar heat radiation as a possible cause of the phenomena. I agree in the view that the ultimate cause must be of cosmic nature, but I think that we have to do here with periodic changes of gravitation rather than of radiation and that we have to seek the proximate cause in the outburst of ice from the Antarctic shelf which is the cradle of all world-wide disturbances in the current system of the globe.

The rhythmical increase and decrease in the intensity of the tide-generating force culminating at the perihelion of the earth and the perigee of the moon exerts its influence upon the internal (and parallactic) tidal waves of the ocean which impinge upon the Antarctic shelf and cause outbursts of ice floes and icebergs and ice melting on a grand scale. This flow of cold Antarctic surface water spreads to lower latitudes and reinforces the three great currents—the West Australian Current in the Indian Ocean, the Humboldt Current in

[13] *Svenska Hydrogr.-Biol. Komm. Skrifter*, No. 5. Discussed by Ellsworth Huntington: Climatic Variations and Economic Cycles, *Geogr. Rev.*, Vol. 1, 1916, pp. 192–202. See also Otto Pettersson: Innere Bewegungen in den Zwischenschichten des Meeres und der Atmosphäre, *Nova Acta Reg. Soc. Sci. Upsaliensis*, Ser. 4, Vol. 6, 1923, No. 2, reviewed by C. F. Brooks, *Geogr. Rev.*, Vol. 15, 1925, pp. 690–691.

the Pacific, and the Benguella Current in the Atlantic—which have their origin in the South Sea either all together or separately. The rotation of the earth imparts to these currents a tendency towards deviation. The deviating force is $D = 2\nu\omega \sin \phi$, where $\nu$ denotes the velocity of the current, $\omega$ the angular velocity of rotation of the earth, and $\phi$ the latitude. An acceleration in the flow of the current therefore increases the deviation, provided that counteracting influences—the ice-melting process and the turbulent friction of the current against the continental slope—remain constant. In the southern hemisphere this deviation is directed westwards, i.e. in this case away from the continental shelf of America and Africa which, as Mr. Murphy says, opened the way for the warm surface water assembled in the bight of Panama (and, we may add, in the Gulf of Guinea) to expand southwards along the South American (and African) coast.

The cause of this increase in the velocity of the Humboldt and the Benguella currents I find in the outbursts of Antarctic ice which, according to the few existing reports, began in 1921–1922. When this ice reached the warmer and salter water outside the Antarctic shelf a greater amount of cold and diluted surface water than usual was generated by ice melting to spread in a northerly direction both in the Pacific and the Atlantic oceans. The observations of the German expedition with the *Meteor*, cruising in the sound south of Cape Horn in January, 1926, where the salinity ordinarily is higher than 34 per mille (according to G. Schott), bear out the fact that the salinity of the surface water in that part of the sea then was unusually low, less than 34 per mille.

# PEARY'S MARCHES

## ON HIS NORTH POLE EXPEDITION, 1909*

Gunnar Isachsen

IN 1908–1909 Peary made his third and last attempt to reach the pole. On September 5, 1909, he wired from Indian Harbour, Labrador, that he had gained it. This declaration was received with doubt, which has continued ever since especially among the great public.

The National Geographic Society in Washington appointed in the autumn of 1909 a committee to examine the question: Chief Geographer Henry Gannett, Admiral Colby C. Chester, and Superintendent O. H. Tittmann—all men well qualified to judge in the matter. After careful examination of the instruments, observations, and log books belonging to Peary and all members of his expedition, the committee arrived at the decision that Peary had reached the North Pole April 6, 1909, adding that the journey was planned and executed by Peary in a manner worthy of the highest praise.

But one thing this committee was not competent to judge, and that is the length of Peary's marches. It is on just this point that doubt arose. That the doubt should continue is quite natural, as none of the few persons who understand this aspect of the matter has given an opinion, so far as I know. That is why I write these lines. And I write now because this doubt has again been raised in the press in connection with the last polar voyages of Amundsen and Byrd.

### Peary's Marches

In 1908 Peary had taken his ship, the *Roosevelt*, to Cape Sheridan, in latitude 82° 27′ N. All the members of the expedition were on the trail the entire winter, hunting or sledging to establish depots northwestwards towards Cape Columbia, 83° 7′. On February 28, 1909, Captain Bartlett began his sledge journey from Cape Columbia with the first group. The following day they were all out on the ice, Peary last, and on their way northwards—in all 24 men, 133 dogs, 19 sledges, with provisions and outfit for 50 days. The distance to the pole from Cape Columbia is 413 nautical miles.

The objective of each day was to reach the pioneer party's camp before the group went further. The parties bunched together the fourth march when the ice broke up in leads during a gale that lasted several days, blowing first from the east and then from the west. For six days they were forced to wait before they could again advance. "Altogether I think that more of mental wear and tear was crowded into those days than into all the rest of the fifteen months we were absent from civilization."[1]

The first support party under Dr. Goodsell turned back March 14 at 84° 29′ N.; the second party, under Borup, March 18 at 85° 23′ N.; the third party, under Marvin, March 26 at 86° 38′ N.; and the fourth and last support party, under Bartlett, April 1, at 87° 47′ N.

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* Major Isachsen discussed this problem on a recent visit to the American Geographical Society and prepared the following translation from his paper "Har Peary vært ved Nordpolen?" *Norsk Geogr. Tidsskrift*, Vol. 1, 1926, pp. 100–104.—Edit. Note.

[1] Robert E. Peary: The North Pole, New York, 1910, p. 228.

From Cape Columbia to the place where Bartlett turned back the daily advance averaged about 12 miles; in the last eight days before Bartlett turned back the marches were about 17 miles. The support parties were consequently used up to the first of April, to 87° 47′ N., a point 133 miles from the pole. From this point Peary went to the pole with the negro Henson, 4 Eskimos, 5 sledges, 40 dogs, and provisions for 40 days. On April 6, at 10 a. m., Peary, according to his observation, reached 89° 57′ N. The last 133 miles (in a direct line) after he parted from Bartlett were done in five marches consequently averaging about 26 miles per day, with 10 per cent added for irregularity of the trail. During his stay of 30 hours at the pole, till April 7, 4 p. m., Peary followed a triangular course, with eight to ten miles to a side, taking at two of the angles observations of the sun in three different directions and at four different times. After these observations the pole was said to be situated at a place within the sides of this triangle. The return to Cape Columbia, where Peary arrived on April 23, was accomplished in sixteen marches, averaging about 29 miles.

Now comes the question: Is it not curious that Peary was able to sledge so rapidly after he had parted from Captain Bartlett, curious that he could do marches averaging about 29 miles from this point to the pole while his marches the last eight days up to 87° 47′ were only 17 miles and he had only averaged about 12 miles from Cape Columbia?

We know that the greater the party the greater the chance that something will go wrong or that the party will be hindered for one reason or another. For instance, a regiment cannot make as good marches as the best company of the regiment, and this company cannot make as good marches as some few picked men of the company. Peary's party on the final spurt for the pole—clearly the most intensive part of the whole expedition—was reduced to 5 picked men and 40 picked dogs. The party was under his personal leadership. He himself was at the head, and all of the party had a feeling that now the moment had arrived when all were to do their best to reach the goal. Therefore the final dash was quick. It had to be quick.

That the return journey from the pole could be rapid and had to be rapid is natural. It was important to reach land before the next full moon, May 3, in order to avoid the obstacles of leads and ice-crushing during the spring flood. Every day the sledges grew lighter and lighter, the snow houses built on the outward journey were of good use, and Peary could follow their old trail, a thing that is of great importance when sledging with dogs. From the moment when Peary parted from Bartlett until the journey was finished the pole party had good, quiet weather and therefore were not much hindered by open leads.

Several of the white members of the expedition had had previous Arctic experience, but the deciding factor during the whole trip to the pole was the help of the Eskimos, capable dog drivers as the Smith Sound Eskimos are. In all, Peary had taken with him from Smith Sound northwards from Cape Sheridan 22 men, 17 women, 10 children, and 246 dogs. He had the best personnel and material that could be procured, and his own experience as an Arctic explorer was second to none.

### Comparison with "Fram" Expedition Marches

In giving my personal opinion with regard to the reasonableness of the length of Peary's marches I will compare his results with our own results during the second *Fram* expedition (1898–1902) under Sverdrup, of which I was a member.[1] After what I have said about Peary's technique, I have only to describe the ice as Peary encountered it and as we found it on the *Fram* expedition in our field of work west of Ellesmere Island and Grant Land.

From Cape Columbia northward to about 86° N. Peary sledged over old ice

[1] Otto Sverdrup: New Land: Four Years in the Arctic Regions, 2 vols., London, 1904.

badly crushed. From this "paleocrystic" ice he entered a belt with many great leads. This belt of leads had stopped him in 1906 when the weather and ice were so unfavorable. From this disturbed belt—the "Big Lead," as Peary termed it—he reached ice of another character, young or "Atlantic" ice, which was not so crushed and piled up and therefore was easier to sledge over.[8]

Several explorers have observed that the ice has another character to the east of Cape Bridgman, the northernmost point of Greenland. To the north of this point the ice is easier to sledge over than that along the northwestern coast of Greenland. This "Atlantic" ice is driven to the east towards the Greenland Sea. But the ice that is pressed against the north coast of Greenland west of Cape Bridgman, against Grant Land, and the islands to the west of Grant Land cannot easily be forced southwards through the narrow sounds between. The ice often lies in these regions year after year, exposed to a heavy pressure, until it becomes paleocrystic. It was this sort of ice that Peary passed through up to 85°–86° N., and it was the same sort of ice that we had to sledge over during the *Fram* expedition and which gives a basis for comparison.

On the second *Fram* expedition we were out sledging during about half of every year for four years. We had not only to sledge but to map and do every sort of exploratory work. But the only object of Peary's journey was to push northward towards the pole. His only concern was to make the longest possible marches northwards. In other words, Peary was exclusively a record breaker.

On our sledging trips we were not content with marches under 15 miles. We often made 20 to 30 miles, and marches of over 30 miles were not rare. Several times we even made marches of over 70 miles. Such long marches show that the sledging is easy and that the distance is eaten up in the good humor of the party and dogs.

If we could make such long marches over ice which may be supposed to have been about the same kind as the ice on the most difficult part of Peary's journey, then even longer ones may be made on better ice such as that which Peary met on his journey to the pole in 1909 to the north of the "Big Lead." It is my opinion that marches of the length of Peary's on his North Pole expedition of 1909 are possible not only for parts of the trip but for the entire journey.

[8] See "The Geography of the Polar Regions," *Amer. Geogr. Soc. Special Publ. No. 8*, pp. 134–135; also on Arctic ice in general in "Problems of Polar Research," *Amer. Geogr. Soc. Special Publ. No. 7*, pp. 91–141.

# MEANDERS IN TIDAL STREAMS: A REVIEW AND DISCUSSION*

**Douglas Johnson**
*Columbia University*

IN a recent bulletin of the Geological Society of America Mr. Marius R. Campbell presents an interesting discussion of the origin of meanders in tidal streams. In the words of the author the main object of his paper is "to demonstrate the proposition that the action of running water at sea level is very different from what it is above that level." Attention is directed first to the well known fact that the lower Mississippi is remarkably free from meanders. As to the cause of the relatively straight course below Baton Rouge, described as occupying a position "at or below" sea level, the author regards the problem as highly complicated and involved; but he is inclined to believe that when the river reaches tide level it flows between banks of stagnant water instead of between banks of earthy material and hence fails to corrade effectively.

Turning to the San Jacinto River of Texas, the author cites the remarkably fine examples of crescentic meander "scars," or scarps cut in the valley walls bordering the drowned lower course of this stream, and recognizes that these scarps were cut by the normal current of the meandering stream when the land stood higher. A later subsidence partially drowned the valley and checked the tendency of the river to enlarge its meander curves. In similar manner the drowned lower course of the James River, also bordered by meander scarps, is cited as an example of a stream which practically ceased its meandering habit when submergence caused the river current to flow through the relatively stagnant waters of the embayment. Here the fact that meander scarps bordering the embayment are no longer being cut by the river current is supported by elaborate argument. It is concluded that in the lower San Jacinto and in the lower James, just as in the lower Mississippi, a stream flowing at tide level has no tendency to form meanders or to cut off meanders formed at some previous period under conditions different from those of the present. The arguments and conclusions are then used in interpreting the geomorphic history of the lower James River and of the lower Potomac River in the vicinity of Mount Vernon.

The reader will follow with interest, and probably without substantial dissent, the author's interpretation of the river histories last referred to; he will enjoy following the arguments with the aid of the excellent sketch maps, especially as the author has made this easy by indicating in parentheses numbers or letters which make possible quick identification of all critical points; and he will give to arguments and conclusions that careful consideration which anything from the pen of Mr. Campbell always commands. Yet he may lay down the paper with doubt both as to the method of argument employed and as to the validity of the chief conclusion reached.

## Lower Mississippi Compared with San Jacinto and James

One prefers when possible to reason from things easily demonstrated to those more difficult to understand. The lower courses of the San Jacinto and James rivers

*Marius R. Campbell: Meaning of Meanders in Tidal Streams, *Bull. Geol. Soc. of America*, Vol. 38, 1927, pp. 537–556.

present no difficult physiographic problems in so far as concerns the partially drowned meander scarps and their significance. It has long been recognized that if a river valley like that shown in Figure 1 be partially submerged, the sea may come to rest against the crescentic meander scarps shown in Figure 2. The lower San Jacinto, the lower Seine, and other embayed streams have been cited as illustrations of valleys of former meandering rivers partially submerged by a change in the level of land or sea. When a river enters the relatively stagnant waters of a broadening estuary

FIG. 1—Block diagram of a meandering river. Abbreviations: m.sp., meander spur; m.sc., meander scarp; f.b., flood-plain bars; f.s., flood-plain swales; n.l., natural levee; h.a., high-level amphitheatre; h.m.sc., high-level meander scarp; h.o.v., high-level oxbow valley; h.c.m., high-level cut-off meander spur; o.l., oxbow lake.

due to such submergence, its current, no longer confined to a narrow channel but free to take a more direct route to the sea, will abandon the outside of its meander curves and flow down a shorter and steeper slope. Such a current, bordered on either side by relatively stagnant water, ceases to corrade the estuarine shores.

If, then, we begin with the simple cases of the San Jacinto and James, the next step is to apply the principles easily demonstrated there to the more problematic lower Mississippi. But this step can be taken only if the physical conditions in the several cases are substantially identical. In the reviewer's opinion the physiography of the lower Mississippi has little in common with that of the two other streams. After all, the lower San Jacinto and lower James are rivers only in name; physiographically they are bays of the ocean, in whose expanded waters unconfined and much diffused river currents move where inertia and gravity lead them. What analogy have they with the lower Mississippi, a true river with its current rather closely confined by earthen banks?

### RELATION OF RIVER LEVELS TO SEA LEVEL

If rivers meander extensively above a certain level, and not at all below that level, the limiting plane should be defined with precision. The author apparently uses the terms "sea level," "tide level," and "tidewater" as synonymous, although these terms are commonly applied to different things, which do not necessarily have the same level. That the difference in level is vital to the author's argument appears clearly in the next-to-the-last paragraph of the paper, where he excludes meandering

runways in tidal marshes as having little or no bearing on this subject, because any lateral cutting effected by the incoming and outgoing tides would be done "above actual sea level." We may assume that here the author has in mind the definite plane of mean sea level and believes (which the reviewer does not) that tidal currents do all their lateral cutting above that plane. Would the author regard sea water moving through these runways with the tides as not within the limits implied by such expressions as "tidewater" and "tide level"? One has an uneasy feeling

FIG. 2—Block diagram of a drowned meandering river. Abbreviations, referring to features partially drowned: m.s., meander scarp; f.b., flood-plain bars; f.s., flood-plain swales; n.l., natural levee; o.l., oxbow lake.

that perhaps meandering tidal creeks demonstrate the ability of streams, under proper conditions, to meander at tidewater or tide level (both above and below mean sea level) and hence that they may constitute a serious objection to the acceptance of Campbell's main conclusion.

If the reader feels that in the matter of meandering tidal runways the author has too summarily dismissed what appears to be an important phase of the problem, this feeling is apt to be reënforced by other parts of his text. James River is recognized as "a tidal stream from Richmond to Hampton Roads, but from the head of tide down nearly to City Point, at the mouth of Appomattox River, the stream behaves more or less as a normal river behaves, and the drowning is not sufficient to submerge the flood plain and carry the water far inland beyond the immediate banks." All this is true of the lower Mississippi; yet the tidal portion of the James here described has good meanders, whereas the lower Mississippi has not. Only low-water elevations are given for the Mississippi; yet it is admittedly during high water that the lateral corrasion of the stream is most effective. At such times the tidal portion of the river is above actual sea level more truly than are the waters of meandering tidal runways.

## GRADUAL CHANGE IN PHYSIOGRAPHY OF LOWER MISSISSIPPI

The change in the behavior of the lower Mississippi does not take place abruptly. Reference to the Mississippi River Commission's maps will show that, while north of Baton Rouge the river shows many meanders and cut-offs, below this point meanders are still pronounced, although evidences of cut-offs are rare or wholly

lacking. Near Donaldsonville the pronounced meanders gradually give place to a pattern characterized by simple bends rather than by true meanders. Not far below New Orleans the simple bends die out, and the remainder of the river's course is for the most part relatively straight or only faintly sinuous. Perhaps it would be most accurate, and likewise most significant, to say that the river changes somewhat gradually from a meandering to a non-meandering course, the three places named being arbitrary division points which serve to emphasize the extent of the progressive change. Any satisfactory theory to account for the non-meandering character of the lower Mississippi must take account of the facts that the change in the river's behavior is progressive and is effected above, not at or below, mean sea level, if due account be taken of the high-water stages. At Baton Rouge high water is approximately 40 feet, near Donaldsonville 30 feet, and a little below New Orleans 18 feet above mean sea level. Incidentally it may be noted that the river is tidal well above Baton Rouge during low-water stages, whereas at high water the tidal influence is scarcely perceptible at Donaldsonville.

If Baton Rouge be selected as the most significant point along the course of a river which alters its pattern gradually, then it is important to note that above and below this point there are contrasts in physical conditions which may be more significant than the one emphasized by Campbell—position of low water with respect to sea level. Some of these differences Campbell has touched on but without complete analysis of their possible relations to the present problem. Other differences may be worthy of consideration, sucn as those in river slope, in velocity of current, in direction and position of current as affected by tides, in proportion of salt water present, in average depth of channel and its possible relation to geologically recent coastal subsidence, and in the nature, height, and slope of the containing levees. Davis has suggested that the extreme tenacity of the mud forming the channel and banks of the Lower Mississippi may retard meandering there, while Powell earlier advanced the idea that near its mouth the silt borne by the river is too fine to serve as a corrading agency. It is possible also that the progressively more recent age of the lower and straighter portions of the river deserves more favorable consideration than Campbell has given this point, especially in view of the probability that sluggish rivers initially nearly straight require an immensely long time in which to develop their first meanders.

## Need of Comparison with Other Streams

Concurrently with consideration of these elements of Mississippi physiography attention should be directed to other tidal rivers which reach the sea without passing through relatively stagnant water of a broadening estuary.[1] The examination should include streams like Maurice River in New Jersey, which meanders extensively where it traverses salt marshes; streams like the Combahee of South Carolina, which meanders through the salt marshes of its lower course and the fresh swamps farther up and in both places apparently with normal vigor, although tidal in both; streams like the Indus, where marked meanders and occasional oxbow lakes appear to exist in the lower, tidal portion, whereas the non-tidal portion immediately above (before the extensively braided section is reached) seems to have a relatively simple pattern, thus reversing the conditions found in the Mississippi case; and other variable types of meandering tidal streams. From such a study there might emerge a satisfactory explanation of the varying behavior of all such streams.

[1] While the present article was in galley proof an excellent study of this type appeared in the *Journal of Geology* for October–November, 1928, pp. 615–629, under the title "Meandering in Tidal Streams." The author, Dr. Donald C. Barton, shows that meandering with cut-offs occurs in the tidal Brazos River, Texas, and discusses a variety of conditions which may affect meandering both above and at sea level.

### A Problem of Terminology

In conclusion it may be pertinent to refer briefly to a problem of terminology. Campbell proposes to apply the name "meander scar" "to any scar that marks the position of a former meander, whether it be on the upland or on the flood plain of the stream." This proposal will interest those who believe that the growth of geomorphology should be accompanied by increasing precision in the use of terms employed in the science. So far as the reviewer is aware, former positions of river meanders are seldom indicated in the topography of an upland surface, for the reason that this ancient element of the landscape has usually been too long exposed to the effacing action of weathering and erosion. Below the upland surface, more or less deeply incised in the land mass but still above the level of present flood plains, are frequently found traces of former meanders, including abandoned oxbow-shaped valleys, old cut-off meander spurs, and high-level amphitheaters open toward the valley lowland. On the present flood plain more recent meander paths are attested by oxbow lakes, crescentic marshy swales and ponds, crescent-shaped bars of sand, as well as by crescentic scarps cut in the valley wall. If the term "meander scar" is to be applied to all these features marking the positions of former meanders, then we must employ other terms to differentiate the various types of meander scars. The accompanying illustrations (Figs. 1 and 2) show a terminology, based for the most part on usages of earlier writers, which the reviewer has found serviceable.

# THE STUDY OF PLACE NAMES
# RECENT WORK AND SOME POSSIBILITIES

John Kirtland Wright

THE many methods which have been followed in studies of geographical names might be grouped under two general heads: (1) accumulative and (2) "ecological."

The accumulative methods are not unlike those of the botanical collector, whose first interest is in gathering and ticketing specimens. The toponym collector draws up lists of place names and garners details regarding the origin and meaning of each;[1] he is concerned primarily with the individual name.

The "ecological" methods—if we may borrow this term from biology—are those in which investigation is made into the nature of the geographical nomenclature in the large and more especially in its relation to the environment, past and present, physical and human. Interest in this case is not confined to or centered upon the individual name.

## American Studies of Place Names

If we may judge from the published literature, the majority of American studies of geographical nomenclature belong essentially in the first category; they have been works of collection and classification, and the results have frequently been presented in alphabetical order. For instance in 1902 Henry Gannett published a 264-page list of selected names of both natural and cultural features in all parts of the United States.[2] As a dictionary of American toponym origins this work is a classic. Immense care was devoted to its compilation. The author carried on an extended correspondence and combed a multitude of publications, the titles of which he gives in a useful bibliography. But he made no attempt at synthesis, and the historical notes are extremely brief. Similar compilations cover particular regions or types of name, as, for instance, E. S. Meany's[3] and Lewis A. McArthur's[4] annotated lists for Washington and Oregon and F. P. Farquhar's study of the place names of the High Sierra.[5]

However, some attempts have been made at analysis and interpretation of various phases of the nomenclature. Even when the main part of a study has taken the form of a listing and commentary upon individual names the author has generally supplied a broader explanatory introduction. Whenever this has been done we have the rudiments of an "ecological" study. Among recent American examples we may mention von Engeln and Urquhart's "The Story Key to Geographic

[1] Two important examples of earlier studies are: J. J. Egli: Nomina geographica: Sprach- und Sacherklärung von 42000 geographischen Namen aller Erdräume, 2nd edit., Leipzig, 1893, and the less ambitious work of Isaac Taylor: Names and their Histories, Alphabetically Arranged as a Handbook of Historical Geography and Topographical Nomenclature, New York, 1896. These are useful alphabetical lists of geographical names with discussions of their origins. Egli appends bibliographical references.

[2] Henry Gannett: The Origin of Certain Place Names in the United States, *U. S. Geol. Survey Bull. 197*, Washington, 1902.

[3] E. S. Meany: Origin of Washington Geographic Names, Seattle, 1923 (also published in the *Washington Historical Quarterly:* Vol. 8, 1917 to Vol. 14, 1923.)

[4] L. A. McArthur: Oregon Geographic Names, Portland, Ore., 1928. See also *Quarterly of the Oregon Hist. Soc.*, beginning Vol. 26, 1925, pp. 309–423.

[5] F. P. Farquhar: Place Names of the High Sierra, Sierra Club, San Francisco, 1926.

Names,"[6] Espenshade's "Pennsylvania Place Names,"[7] and Fitzpatrick's "Nebraska Place-Names."[8] A brief discussion by W. A. Read, "Research in American Place Names, c. 1920–26: a Partial Review," has recently appeared.[9]

## The Ecology of the Place Name Cover

We have used the term "ecological" in this connection because there is an analogy—not perfect, by any means, but striking enough—between the vegetation cover and what we might conceive to be a place name cover spreading over the landscape. Just as many plant formations contain a gradation of elements between those that are just becoming established and those that are dying out, so we have for any given region a group of names that are coming into use, others that are fully accepted, and still others that are disappearing. There are also names that might be called dead—that is, that have been completely abandoned in local usage and are found only on old maps or in other records.[10]

The living names in any particular district at any particular time are an accumulation from the past, the quality and the density of which depend partly upon the density of the population, partly upon the length of time during which the country has been occupied and upon the character of the various waves of settlement that have swept through it, and partly upon the nature of the ground. If the topographical aspect of a region or the character of the population and language spoken within it changes materially there will be a corresponding alteration in the name cover. This alteration, however, is likely to be exceedingly slow. European experience has shown that a place name, once established, is often even more enduring than a nation or a language. On July 3, 1790, a group of classical names was officially bestowed by the Land Office in New York City upon twenty-five unsettled townships in western New York state: Lysander, Hannibal, Cato, Brutus, Camillus, Cicero, Manlius, Aurelius, Marcellus, Pompey, Romulus, Scipio, Sempronius, Tully, Fabius, Ovid, Milton, Locke, Homer, Solon, Hector, Ulysses, Dryden, Virgil, Cincinnatus.[11] Nearly a century and a half of ridicule has not sufficed to remove these names; and it is probably safe to predict that, like the many pre-Celtic toponyms still in use in France[12] and England, they will persist—modified in form, to be sure—even when the English tongue itself has become one of the dead languages.

The place name cover in western Europe is very dense and its interpretation extremely complicated. Development has been proceeding through so long a period and has reflected so many linguistic and historical changes that origins and original meanings are often obscure or inexplicable. In the United States, on the other hand, since in most cases we possess the records of the early settlers who applied names to administrative subdivisions and natural features, the problem is simpler. Our names, except those bestowed by Indians, French, and Spaniards, have not been subjected to radical changes in their linguistic environment. The interpretation

[6] O. D. von Engeln and J. M. Urquhart: The Story Key to Geographic Names, New York and London, 1924. A book for children, intended to enliven the study of geography by giving explanations of the principal geographic names employed in all parts of the world.

[7] A. H. Espenshade: Pennsylvania Place Names, State College, Pennsylvania, 1925. Entertaining historical notes on the origins of county, town, and village names, with a brief classification.

[8] L. L. Fitzpatrick: Nebraska Place-Names (Univ. of Nebraska Studies in Language, Literature, and Criticism, No. 6), Lincoln, Neb., 1925. Brief notes on origins of town, village, railroad station, and post office names, arranged alphabetically by counties and preceded by a brief classification.

[9] *Zeitsch. für Ortsnamenforschung*, Vol. 4, 1928, pp. 185–191.

[10] Many abandoned names in the middle west are listed in [W. H. Stennett]: A History of the Origin of the Place Names Connected with The Chicago & North Western and The Chicago, St. Paul, Minneapolis, & Omaha Railways, Chicago, 1908.

[11] Charles Marr: Origin of the Classical Place Names of Central New York, *Quart. Journ. New York State Hist. Assn.*, Vol. 7, 1926, pp. 155–168.

[12] See *Geogr. Rev.*, Vol. 15, 1925, p. 658, à propos of Auguste Longnon: "Les noms de lieu de la France, leur origine, leur signification, leurs transformations," Paris, 1920–1923.

of Indian names, however, demands highly technical knowledge, especially because many of these aboriginal designations have undergone violent transformations during the centuries that they have been maltreated on the tongues of white men.[13] "Kearsarge" and "Connecticut," for example, represent words originally pronounced in some such manner as *koowass-adchu* and *quinni-tuk-ut*.[14]

## Stabilization of the Place Name Cover

In many parts of the United States the geographical nomenclature is not altogether established. Writing in the seventies of the nineteenth century, M. F. Sweetser in his guidebook to the White Mountains pointed out that different names were often given to a single mountain by people dwelling on different sides.[15] Such differences do not usually lead to bitter feeling, as in the case of the famous dispute between the inhabitants of Tacoma and Seattle about the name of the great mountain overlooking Puget Sound. But that there is still no little confusion in the White Mountains the writer knows from personal experience. Even the name "White Mountains" itself is flexible, the term frequently being applied by natives of northern New Hampshire and northwestern Maine to the highest (or Presidential) range only, whereas others who dwell at a greater distance extend the limits of the White Mountains over a wider radius. The influx of a new type of settler or visitor often tends to bring about changes in names, particularly when the newcomers are of a different educational and cultural background from the original settlers. City people coming to the White Mountains for the summer have often endeavored to substitute names more euphonious than those used by farmers and lumberjacks. The reaction of the urban type of mind to some genuinely rural names in New England was thus expressed by Sweetser: "Nomenclatural degradation is found in the various Hog-back Mountains, and the villainous names given to the fine peaks of the Ossipee Range, which are called the Black Snouts by the neighboring rustics."[16] By fiat of the U. S. Geographic Board the names of many of the mountains on Mount Desert Island have been changed.[17] Green Mountain, the highest summit, becomes Cadillac Mountain, Newport becomes Champlain Mountain, Robinson becomes Acadia Mountain, Brown's becomes Norumbega Mountain, and Dry becomes Flying Squadron Mountain. These artificially chosen names are thought to be more appropriate in a National Park than the homelier designations bestowed by the pioneers.

In the United States the carrying out of surveys, the publication of authoritative government maps, and the decisions rendered by the Geographic Board are exerting a powerful influence toward the fixation of the geographical nomenclature. Stabilization is also being promoted through a development of historical interest which leads to the investigation of old place names and active propaganda for their preservation.[18]

## Social Basis of the Place Name Cover

The manner in which the geographical nomenclature may reflect the social character of the groups of people who have actually occupied a country and have

[13] An exceptionally interesting study of the Indian place names and their relation to environment is that of T. T. Waterman: The Geographical Names used by the Indians of the Pacific Coast, *Geogr. Rev.*, Vol. 12, 1922, pp. 175–194.

[14] J. H. Trumbull: The Composition in Indian Geographical Names, Illustrated from the Algonkin Languages, reprinted from *Connecticut Hist. Soc. Colls.*, Vol. 2, Hartford, 1870, pp. 8, 20.

[15] M. F. Sweetser, edit.: The White Mountains: A Handbook for Travellers, 4th edit., Boston, 1881, p. 31.

[16] *Ibid.*

[17] Decisions of the United States Geographic Board, Oct. 2, 1908.

[18] See, for example, H. W. Shoemaker: Place Names and Altitudes of Pennsylvania Mountains, Altoona [1923?]. (Address at quarterly meeting of Wyoming Historical and Geological Society, Wilkes-Barre, Pa., March 9, 1923.)

created the name cover was discussed several years ago by Professor Whitbeck in an entertaining article on regional peculiarities of place names in the United States.[19] Whitbeck picked out several typical regions, comparing the character of the names in each and explaining the reasons for the differences. For example, such New England town names as Barkhamstead, Farmington, Hartford, Manchester, Glastonbury, etc., reveal a strong influence of old England and "evidence of both culture and character." The New England administrative system, under which the whole countryside is subdivided into "towns," led to the frequent use of adjectives, North, South, East, West, and Center, in designating the villages within each township—thus, East Lebanon, Center Lebanon, West Lebanon, or even East North Yarmouth. Such directional adjectives are not found in the South and West where the county was the fundamental administrative unit. A very different type of name is exemplified in northern New Jersey. Whitbeck writes of such "cool and balmy names" as Allendale, Bloomingdale, Pleasantdale, Maplewood, Wildwood, etc., which "spring up in profusion only in regions where city influence is strong." Such names were frequently applied in the first instance by real estate agents with a view to attracting urban dwellers into the suburbs. In Tennessee the limited imagination and education of the mountaineers has led to names like Arc, Aunt, Bee, Fry, Fly, Gum, Kate, Lucy, etc.

### Physiographic Basis of the Place Name Cover

To place name cover in relation to the earth's surface itself less attention has been devoted by American students than to its historical and social aspects. Comparative studies in the relative density, distribution, and quality of names in regions of varying topography would be well worth while. That there is a field here for investigations of considerable interest has been shown by European scholars.

For example, a way in which place names may preserve a record of former topographical conditions has been pointed out in a recent article by Wilhelm Troll, who reconstructs the probable distribution of the forests on the glacial soils in the vicinity of Munich before the Thirty Years' War largely from the evidence supplied by toponyms correlated with the terrain.[20]

The relative abundance of names, or density of the place name cover, depends upon a variety of circumstances. In thickly settled territory names are naturally abundant, but they are also profuse in districts that are frequently visited but not permanently occupied. Thus, to revert to the White Mountains, the highest peaks, tramped over every summer by climbers and tourists, literally bristle with place names, every ravine, every ridge, and many a boulder, cliff, and crag having its recognized designation. On the other hand, in the outlying mountains which are rarely visited except by loggers, fishermen, and berry pickers the names are more widely separated, and there are many prominent but quite nameless summits, ridges, and watercourses.

The minor topographical features to which permanent names are affixed vary in different parts of the world. Nearly everywhere bodies of water and the larger elements of the relief (hills, mountains, cliffs, etc.) are named.[21] On the other hand, there are great divergences in custom governing the use of names for the vegetational elements, such as forests, groves, meadows, pastures, moors, fields. In the eastern United States woods and forests rarely have acquired distinctive names—perhaps by reason of their often indefinite extent and their lack of permanence. In Europe,

[19] R. H. Whitbeck: Regional Peculiarities in Place Names, *Bull. Amer. Geogr. Soc.*, Vol. 43, 1911, pp. 273–281. See also J. J. Egli: Der Völkergeist in den geographischen Namen, Leipzig, 1894. (Sonderabdruck aus dem *Ausland*, 1893.)

[20] See *Geogr. Rev.*, Vol. 17, 1927, p. 492, à propos of Wilhelm Troll, "Die Bedeutung der Ortsnamen für die pflanzengeographische Forschung" (*Zeitschr. für Ortsnamenforschung*, Vol. 2, 1926, pp. 12–31).

[21] For an interesting exception to this generalization, see Waterman, *op. cit.*

on the other hand, forests, copses, and woods, generally acquire enduring designations. If we examine one of the inch-to-the mile Ordinance Survey maps of the rural districts of England we note many names by which farms and estates have been known for generations. These names are part of the established place name cover. This is hardly true in the United States; property is usually spoken and thought of as "Robinson's" or "Smith's" even though Mr. Robinson may call his farm "Bonniebrook" on his letterheads and Mr. Smith may sell his apples or peaches under the trade name "Hilltop Farm."

Nor are the natural or physiographic regions of the United States recognized by distinctive names, except occasionally by geographers and naturalists or where they present a striking contrast to neighboring regions—as in the case of the plateaus of the southwest, or the Black Belt of Alabama, Georgia, and Mississippi, or some of the prairies of Texas.[22] We have nothing analogous to the names of the *pays* of France, which, as Gallois has shown, correspond essentially to well-defined lesser natural regions.[23] A Frenchman may refer to the little town of Voves, southeast of Chartres, as either in Eure-et-Loire, or in Orléanais, or in the Beauce. The first is the name of the *département*, the fundamental administrative subdivision. On the whole, however, the departmental names are probably less frequently used in everyday speech than the provincial names dating from before the French Revolution (Orléanais, Bretagne, Touraine, etc.) or than the *noms de pays* (Beauce, Woevre, Argonne, etc.) The provincial and regional names, though officially obsolete and without governmental recognition, are living territorial designations of the different parts of France; and, despite more than 130 years of organization by *départements*, the latter are still generally regarded as artificial. To change our comparison from ecology to paleography, we might liken the territorial nomenclature of France to a palimpsest, in which the older names stand out distinctly beneath the superimposed layers of later administrative nomenclatures.

In the United States, on the other hand, our administrative subdivisions were usually established coincidentally with, or occasionally even before, settlement; and the administrative names are in most cases the only territorial designations in use. Thus there is no other way of referring to the town of Harvard except by relating it to existing administrative units. Thus we must say "Harvard lies in eastern Worcester County, in the east-central part of Massachusetts," even though this town stands upon a block of upland country which is fairly well defined by river valleys and which, were it in France, would doubtless have its own distinctive name.

[22] See R. T. Hill: Geography and Geology of the Black and Grand Prairies, Texas . . . *21st Ann. Rept. U. S. Geol. Survey, 1899-1900, Part VII, Texas*, Washington, 1901, p. 26.

[23] Lucien Gallois: Régions naturelles et noms de pays, Paris, 1908.

# AMUNDSEN: SUPREME ADVENTURER

John H. Finley

THE tragic end of Amundsen's terrestrial career was after all the most poetically fit and glorious that could crown such a life of exploration and adventure. A polar sea could alone give him appropriate sepulture. It was fit too that he should find his last sea grave near the shores of his Viking land. That he came to his death in seeking through the Arctic mists to rescue those who could not even be called "friends" makes his last voyage his supreme adventure. He who made himself doubly immortal in his conquest of both poles of the earth has added a third palm to his immortality.

Sir Thomas Browne, in his "Religio Medici," expanded Lucan's line "coelo tegitur, qui non habet urnam" into one that may most aptly be applied to him:

> He that unburied lies wants not his Herse,
> For unto him a Tomb's the Universe

Amundsen belongs to the universe in a particular sense. Not only did he attain the uttermost ends of the earth: but also those far older and yet more romantic objectives, the Northwest and Northeast Passages, from the search for which interest in the polar regions had first proceeded. While he followed Nordenskiöld in sailing the Arctic Sea eastward from Atlantic to Pacific he was actually the first to navigate that sea westward from ocean to ocean. What was the formula of his almost magical success?

"Exploration," he says in "My Life as an Explorer," "is a highly technical and serious profession." He saw it as an end in itself, and he brought it to high perfection. The requirements for this profession are "a sound and trained body" and a "specialized mental equipment." The latter, he continues, is "informed regarding the experience of all preceding expeditions." It is a notable commentary on one who spent so much of his life in the wilderness. "Secondhand experience out of books is often as good as firsthand, if the reader has had enough practical experience in the same field to understand and apply what he reads." Here is a basis of wise judgment. He made the Northwest Passage by following a suggestion gleaned from M'Clintock and taking a course through Simpson Strait, south of King William Island, a course rendered possible furthermore by his selection of a small shallow-draught boat: his vessel, the little *Gjöa*, was only 47-tons register. Best example of all is his choice of a base for the dash to the South Pole. The Bay of Whales, a stable point on the floating ice of the Great Barrier, was chosen "as a result of careful comparison of every existing description of that part of the Antarctic glacier, from its discovery." The difficulties encountered by Scott in his contemporary march farther west proved the wisdom of Amundsen's decision. It was the sound deduction, backed by the courage to put his theory to the test, that marks his feat as heroic. It is precisely like Nansen's test of his conclusions regarding Arctic currents by the drift of the *Fram*. Amundsen, indeed, was inspired by Nansen, whom he acclaims as a pioneer in the theory and practice of polar exploration. Nansen he followed specifically in his use of light equipment, of dogs for motive power, and of concentrated food for men and beasts.

The explorer by ship is advisedly a trained navigator. Amundsen recognized this asset at an early date and found justification for it in his own experiences as first mate on the *Belgica* in the Antarctic, 1897–1899. The explorer's equipment

also should include "a thorough understanding of the scientific problems in the solution of which his explorations can have an essential part." Speaking of the preparation for the Northwest Passage, he says "My expedition must have a scientific purpose as well as the purpose of exploration. Otherwise I should not be taken seriously and should not get backing." In pursuance of this policy he undertook careful training in the study of terrestrial magnetism, with what admirable result is shown by his two-year series of magnetic observations from the vicinity of the North Magnetic Pole. Of similar order are the meteorological observations at Framheim, Amundsen's South Polar winter station, and the magnetic, meteorological, and oceanographical results obtained on the *Maud* during the Norwegian North Polar Expedition, 1918–1925 under the scientific direction of H. U. Sverdrup.

It was a rare combination this: painstaking purpose and scientific preparation fired by high spirit of adventure. Till the end came, as we must presume some time shortly after June 18 last, it carried through to unrivaled success this "supreme adventurer," as he is called by his friend and old comrade, Lincoln Ellsworth.

# AMERICAN GEOGRAPHICAL SOCIETY

**The November Meeting.** The first regular meeting of the American Geographical Society for the season 1928–1929 was held on November 20, 1928, at the Engineering Societies Building, 29 West 39th Street, President John H. Finley in the chair. Mr. Herbert E. Bradley addressed the Society on "An Unknown Cannibal Country in the Belgian Congo." Mr. Bradley conducted an expedition (1924–1925) into the territory west of Lake Edward in the Belgian Congo. There he found primitive African life, untouched by civilization, and obtained an unusual set of motion pictures of the cannibal Bahuni as well as of the extraordinary animal life in which the country abounds.

**Elections to Fellowship.** At the November meeting of the Society, President Finley presiding, there were presented with the approval of the Council the names of 522 candidates who were duly elected as Fellows of the Society.

**Presentation of the Samuel Finley Breese Morse Medal to Captain Sir Hubert Wilkins.** At the last regular meeting of the Society for the season 1927–1928, held on April 24, the Samuel Finley Breese Morse Medal was awarded to Captain Sir Hubert Wilkins (*Geogr. Rev.*, Vol. 18, 1928, p. 496). At a luncheon on July 3 presentation of the medal was made by Mr. Philip W. Henry, Chairman of the Council. "We are here to honor a man experienced both in exploration and aviation," said Mr. Henry, briefly recapitulating Captain Wilkins' work up to the epoch-making flight.

"On April 21, 1928, the world was electrified to learn of the successful flight from Point Barrow to Spitsbergen, a distance of over 2000 miles, the greatest airplane achievement in the polar regions. As a feat in navigation, it is unexampled; for the proximity of the magnetic pole, the necessity of crossing at an acute angle so many meridians in high latitudes, and the small area of his island destination made the problem unusually difficult. But it was solved perfectly; and for his great achievement he has received the plaudits of the world—from the geographer and scientist to the man in the street. Like all true-hearted men, he gives due credit to those who made possible this successful outcome and has expressed in the most positive way how much he owed to the skill and courage of his pilot, Lieutenant Eielson, who is with us today. From a geographical standpoint this trip brought to view a lane of territory over 2000 miles in length, the greater part of which had never before been seen by the eye of civilized man. Although no new land was discovered, his path covered a section where there was a possibility of land and where Peary thought he had seen it.

"More than all, this trip demonstrated the soundness of the conclusions which our explorer had expressed in his article entitled 'Polar Exploration by Airplane' in the recent volume published by the American Geographical Society on 'Problems of Polar Research,' to which thirty-one experts on polar problems contributed. Such achievements are worthy of recognition, and there has been no lack of this on the part of European civic and scientific bodies, many of which have honored him with medals and other marks of favor. As an Australian he has been knighted by his King. The American Geographical Society was the first to pay tribute in the form of a medal available under a bequest made in 1872 (but not founded until 1902) by Samuel F. B. Morse, himself an explorer in the realm of electricity. In the words of the founder, the medal is to be presented 'for the encouragement of

geographical research.' It is interesting to note that the first medal is given to one who used in 'geographical research' a means of transportation unknown in Morse's day and one which at that time was considered an unrealizable dream by many prominent scientists. It will also be observed that during his flight the explorer sent messages, transmitted through the air—an advance over Morse's invention—thus keeping the world informed of his movements.

"In view of the endorsement and support originally extended by the American Geographical Society, and in view of his great achievements, it gives me particular pleasure to present, in behalf of the Society, the Morse Gold Medal to our distinguished guest, Captain Sir Hubert Wilkins. In presenting you, Sir Hubert, with our medal we not only wish to do honor to the work you have done in the Arctic but to signify our confidence in your plans for the work that lies ahead of you in the Antarctic."

In responding, Captain Wilkins thanked the Society for its unfailing support of his Arctic work and presented it with an American flag which he had carried with him in his flight. Captain Wilkins then described in some detail his plans for further work in the Antarctic.

## Recent Publications

**Map of the Antarctic and Navigational Chart of the Antarctic.** These maps have been designed to meet the needs of those who wish to follow current Antarctic exploration. Specifically they were prepared for use by the expeditions of Commander Richard E. Byrd and Captain Sir Hubert Wilkins, now in the field. The map of the Antarctic is on a scale of 1:4,000,000 and is printed in black and white and blue, in four sheets each 32 inches square. This size permits adequate representation of the known data. It incorporates the work of all the major expeditions of the last thirty years, among them those of Shackleton, Scott, Amundsen, the *Belgica*, Charcot, Mawson, Drygalski, Nordenskjöld, Bruce, and Filchner and, in so far as it has not been superseded, the work of the earlier explorers and seamen.

The known extent of the inland ice is shown and the glaciers at its margin, together with the shelf ice and the border of the free-swimming ice pack as observed by past expeditions. Relief of the inland ice and the small areas of ice-free land are shown by generalized contours at 1000-meter intervals; many individual heights are given and also the profiles of Amundsen's and Scott's routes from the Ross Barrier to the Pole, which are here reconciled for the first time. Dr. Simpson's conclusion that Scott's value (elevation of the South Pole 2765 meters, or 9072 feet) was a closer approximation to the truth is accepted. Practically all known soundings in Antarctic waters are represented on the map, while the more abundant data permit drawing of bathymetric contours at 200, 500, and 1000 meters and thence downward for each 1000 meters. Lines of equal magnetic variation are shown for 1927. The network of geographical coördinates is drawn for every degree to facilitate the plotting of new data as they are received.

The large scale and the use of color bring out very graphically how enormous is the area of Antarctica that is still quite unknown. Only narrow belts of territory have been mapped of a total land mass that is possibly twice as great as the United States. The two-thousand-mile stretch between Graham Land and Ross Sea is totally unknown; and, except for two landfalls, so is the whole opposite coast of the continent for nearly a third of the way round the globe in that latitude.

The Navigational Chart of the Antarctic, on a scale of 1:12,000,000, which accompanies the above map is made for use in aircraft navigation. It is identical with that supplied to Commander Byrd and Sir Hubert Wilkins. It shows the outlines of ice and land as far as known and the lines of equal magnetic deviation. Its use is explained in a pamphlet accompanying the maps.

Richard **Hakluyt and the English Voyages.** The Society announces the publication of a volume of this title by George Bruner Parks, Ph.D., Professor of English at Washington University, St. Louis. This is the first adequate life of the famous editor of the *Divers Voyages* and *Principal Navigations*. Hakluyt is shown to have been not merely a compiler of narratives of exploration and overseas ventures but a practical geographer and promoter of English colonial and mercantile enterprise. Geographical science in England in the Elizabethan Age is discussed in full. Dr. James Williamson, authority on English expansion in this period and author of a recent biography of Sir John Hawkins, has contributed a brilliant introduction.

**Northern Neǧd: A Topographical Itinerary.** This volume, by Professor Alois Musil, is Number 5 of the Society's series *Oriental Explorations and Studies* (see *Geogr. Rev.*, Vol. 15, p. 297; Vol. 17, pp. 145, 178; Vol. 18, pp. 144, 497). It contains the narrative of a journey carried out in Nejd in the winter of 1915. Leaving Al-Jauf in January Musil skirted the little-known eastern margin of the Nefūd desert to a point about two hundred miles east-southeast from Ḥāyel. Here he spent some days in extremely hazardous but unsuccessful political negotiations with the young Shammar emir, Sa'ūd ibn Rashīd. Thence Musil made his way west to Al-'Ela' on the Ḥejāz Railway and from there eastward again, first along the southern fringes of the Nefūd and then by way of the old Pilgrim Route to Iraq. The appendixes, besides detailed discussions of various matters relating to the medieval history of certain places in Nejd and along the Pilgrim Route, include detailed narratives of the history of two families of Ibn Sa'ūd and Ibn Rashīd who have ruled over central Arabia since the eighteenth century. There is also a critical refutation of arguments that have been adduced tending to prove that Arabia has been the scene of progressive desiccation since antiquity.

**Medals and Medalists.** Under this title there has been published a booklet on the four medals awarded by the Society for distinguished work in exploration and geographical science. It contains a brief description of the Society's activities and publications, a statement of the founding and conditions of award of each medal together with a list of recipients to date, and a group of selected presentation addresses by officers of the Society and by diplomatic representatives of the United States who have acted on behalf of the Society. It is illustrated with photographs of the obverse and reverse sides of each medal. "Medals and Medalists" will be sent to any Fellow of the Society on request.

**Distribution of Title Page, Contents, and Index of Volume 18 of the Geographical Review.** The title page, table of contents, and index for Volume 18 of the *Geographical Review* (1928), which is issued separately, is ready for distribution. Copies are sent to all institutions exchanging publications with the Society and to individuals who request that their names be put on a list for this purpose.

# GEOGRAPHICAL RECORD

## NORTH AMERICA

**Waddington Mountain, the Highest Peak in British Columbia.** In the April, 1928, number of the *Geographical Review* there appeared an article on "Mystery Mountain," the name tentatively applied to a lofty peak of the Coast Range of British Columbia explored by the author, Mr. W. A. Don Munday, and his party. The name "Mt. George Dawson" was also proposed. The final decision of the Geographic Board of Canada, reached on April 3, 1928, makes the name "Waddington Mountain." The mountain has been definitely located and its elevation measured by a survey party working under the direction of the Survey Branch, Department of Lands of British Columbia. The triangulation survey was completed on September 10, 1927. It gives the geographical position of the mountain as latitude 51° 22′ 32″ North, longitude 125° 15′ 34.5″ West; the elevation as 13,260 feet above mean sea level.

This is the highest mountain in British Columbia, as far as known today, with the exception of Mt. Fairweather (15,287 feet) on the boundary between the Province and Alaska and only partly in British Columbia. There is little possibility that any other height will be found in British Columbia surpassing that of Waddington Mountain, yet its existence remained unnoticed until recent years.

The mountain is named for Alfred Waddington, one of the most enterprising of the pioneers of the Province. He went from England to the gold fields of California in 1849 and thence in 1858, when gold was discovered in the Fraser River area, to British Columbia. When the richness of the Cariboo gold fields was established he conceived the idea of constructing a wagon road from the head of Bute Inlet up the Homathko River to Fort Alexandria and thence to the Cariboo mines. In the prosecution of this idea he spent almost his entire fortune and, in spite of great difficulties, carried forward construction of the road until April, 1864. At that time certain Chilcotin Indians murdered nearly the whole personnel of his camp of road makers and destroyed his stock of tools and provisions, defeating his plan.

Waddington was among the first to urge the construction of an all-Canada railway from eastern Canada to the Pacific, submitting a possible western route. He died in Ottawa in 1872, just a few years before the construction of the Canadian Pacific Railway which made a reality of the project he had urged.

GEORGE G. AITKEN

**New Hampshire Mountain Rainfall.** That mountains have heavier rainfall than the lowlands at their foot is a well known fact, though actual measurements of mountain rainfall are few and far between. Ahlmann obtained some valuable records on the Norwegian *fjells* which he used in preparation of a new rainfall map of the Scandinavian Peninsula (see review by Professor Jefferson, *Geogr. Rev.*, Vol. 16, 1926, pp. 494 and 495–497). The measurements obtained on top of Mt. Washington over a period of seventeen years, showing an average rainfall double that at the base, are repeatedly instanced. Now, forty years since the Mt. Washington observations closed, a new series of mountain rainfall observations in New England has been initiated. It is a response to the floods of November, 1927, when our meager knowledge of the rainfall factor was forcibly brought home (J. W. Goldthwait: The Gathering of Floods in the Connecticut River System, *Geogr. Rev.*, Vol. 18, 1928, pp. 428–445).

In "Summer Rainfall on New Hampshire Mountains" (*New Hampshire Highways*, Vol. 6, No. 6, September, 1928), Professor J. W. Goldthwait has summarized the results of the first available records. During July and August, 1928, rainfall figures were received from eighty stations in New Hampshire, mostly conducted by volunteer observers, where there had previously been only a dozen. Many were located in the mountains and others in adjacent valleys, offering lowland contrasts. Gorham, near the base of Mt. Washington at 800 feet elevation, had 5.32 inches of rainfall; Halfway House had 12.24 inches; and at the top, 6270 feet, 15.26 inches of rain were registered. Two stations, Madison Hut and Lake of the Clouds, which showed apparently deficient rainfall in proportion to their altitudes, are located in sheltered positions. Monadnock had 19.21 inches; Keene, 2600 feet lower, had 11.89 inches; and so for other pairs of mountain and lowland stations.

Since the heaviest rainfall of New Hampshire occurs in summer as a result of local thunderstorms, its quantity and distribution vary greatly within the state and from year to year. From selected cases which seem to be representative it can, however, be stated that the "mountain tops show from one and a half to two times as much rainfall during July–August 1928, as the valleys." Publication of the records for the remainder of the 1928 season will be awaited with interest.

**Specialized Farming in Massachusetts.** The Massachusetts farmer, no longer able to raise all he needs at home, is being forced either to leave the farm or to produce cash crops for local markets. In order to compete with the more fertile land farther west, the products of which have been made available by improved transportation, he must specialize in products too perishable or too bulky for long distance shipment. A study of data for towns derived from the United States Census of Agriculture taken in 1925 has enabled Ronald L. Mighell and Marian Brown to distinguish thirteen areas in Massachusetts in which different types of specialized farming have been developed (Type-of-Farming Areas in Massachusetts, *Mass. Agric. Exper. Sta. Bull. No. 244*, June, 1928). This publication is illustrated by a hypsometric map of the state and by dot maps showing farm population, number of farms, value of land and buildings, crops, and distribution of farm animals. These maps give a more detailed representation of the distribution of agricultural activities in Massachusetts than it would be possible to compile from the published report of the United States Census of Agriculture, since the smallest territorial unit for which statistics are given in the latter is the county. The statistics which made possible the construction of the maps were specially tabulated by the Census Bureau for the Massachusetts Department of Agriculture but have not been published.

Near Boston, Springfield, Fall River, and New Bedford, areas of specialized market gardening and poultry and egg farming have developed. Beyond these and extending into the hillier country are dairy districts. Rougher land is used for orchards, and in the mountainous regions woodlands and pasture predominate. Cranberry production is directly related to the occurrence of bog land in Plymouth and Barnstable counties, and tobacco culture to the fertile soil of the Connecticut Valley.

## SOUTH AMERICA

**The Bolivia-Paraguay Boundary Dispute.** The Buenos Aires conferences on the Bolivia-Paraguay boundary dispute in the Chaco region which were convened as the result of an agreement signed at the Bolivian Legation at Buenos Aires on April 22, 1927, were closed by joint consent in July, 1928. At the final session it was decided to attempt again to settle the dispute by direct negotiations between the Foreign Offices of the two governments and, in case that failed to resort to arbitration. Subsequent incidents indicate the futility of attempting settlement by the former method; and as regards the latter there is disagreement both as to the arbi-

trator and as to what is to be arbitrated. Paraguay wants a *status quo* of present occupancy established on which future negotiations are to be based. Bolivia bases all her claims on the status of the common boundary between the colonial administrative divisions which became the independent republics of Bolivia and Paraguay after the overthrow of Spain. This status, technically known as the *uti possidetis* of 1810, has been the basis and the stumblingblock of all the major boundary disputes in Latin America. In no instance have the royal decrees which established the administrative divisions of the colonial system been so clearly stated as to permit of only one interpretation. Bolivia bases her claim to the whole of the Chaco region west of the Paraguay River and mouth of the Pilcomayo on a series of royal decrees of the sixteenth century in which, it is claimed, the Audiencia of Charcas, from which the Republic of Bolivia was created, was established and later extended to cover the area of the Bolivian claims. Paraguay claims that, when the Audiencia of Charcas was divided into two provinces in the early part of the seventeenth century, the new province included the whole basin of the Paraguay River and that, of the three districts into which it was divided, the district of Paraguay (from which the Republic of Paraguay was finally created) included not only the area east of the Paraguay River to which Bolivia would confine Paraguay but the whole basin of the river north of the Pilcomayo.

FIG. 1—Map illustrating the course of the Bolivia-Paraguay boundary dispute. Scale 1:13,000,000.

It was not until 1877, after Bolivia had lost her provinces on the Pacific, that she approached Paraguay for a boundary treaty, her chief object being to secure a river port on the Paraguay or the Pilcomayo that would give her access to the Atlantic. When President Hayes in 1876 arbitrated the Paraguay-Argentine dispute and established their boundary in the Chaco along the Pilcomayo River, Bolivia made no claim to any interest in the transaction. The various boundaries fixed by successive treaties, of 1879, 1887, and 1894, none of which were ratified, are shown on the accompanying map. Negotiations were again resumed in 1907, and the Pinilla-Soler protocol was signed which established a tentative boundary but in such vague terms that it has only led to further difficulties. An agreement of 1913 nullified all previous negotiations, but Paraguay still holds to the line of the Pinilla-Soler protocol of 1907 as the frontier.

As to the actual settlement and development of the Chaco region, it appears that Paraguay has made the more consistent and permanent efforts. Bolivia has established military outposts on the Pilcomayo River as far as the Esteros de Patiño and on the upper Paraguay maintains a wireless station at Puerto Suárez and has effectively occupied the territory from there westward to Santa Cruz de la Sierra. The Bolivian Government has fostered many colonization projects in the Chaco and made large grants of land to local and foreign development companies, but none have resulted in permanent settlement. Paraguay, on the other hand, has been

steadily pushing out into the Chaco for many years. Fort Olimpo on the Paraguay River was established in 1792 and has always been held by Paraguayan troops.

After the failure of the Bolivian National Convention to ratify the Quijarro-Decoud Treaty of 1879, Paraguay began to settle colonists as far north as the 21st parallel. When Bolivia again failed to ratify the Tamayo-Aceval Treaty of 1887, Paraguay moved her outposts as far north as Puerto Pacheco and has remained in possession there since that time. Paraguayan and foreign interests have been granted concessions at many points west of the river south of Fort Olimpo for quebracho lumbering and cattle raising, and a number of roads and short railway lines have been built from ports on the Paraguay River to these concessions. The latest attempt at colonization by Paraguay on a large scale is the concession granted to Canadian Mennonites, which extends beyond the line of the Ichazo-Benites Treaty of 1894 (see John W. White: The Great Mennonite Migration to Paraguay, *Bull. Pan Amer. Union*, Vol. 61, 1927, pp. 432–442).

The Bolivian Government, meanwhile, has recently declared its intention to devote its efforts toward agricultural development to those areas on the highlands and in the upper valleys of the eastern slopes of the Andes that are now under cultivation, postponing all efforts toward the colonization of the Chaco to some future time when areas now under cultivation have reached their maximum productivity and the increase in population demands new lands.

**Reconnaissance Map of the Pichis-Pachitea River System.** Attention is called to the reconnaissance map of the Pichis-Pachitea rivers, Peru, made by Messrs J. T. Singewald and E. C. Roschen in 1925 and published on a scale of approximately 1:480,000 in the June, 1928, number of the *Bulletin of the Geological Society of America*. The Brunton compass was used for direction, and distance along the river bank was estimated; the traverse was tied to astronomically determined points at Masisea, Puerto Victoria, Puerto Bermudez, and two other stations. The Pachitea, with its tributary the Pichis, offers certain advantages as a route from the montaña to the Amazon. The course is free from the dangerous canyons, cataracts, and whirlpools that characterize the Marañon and Huallaga rivers and is also safer and more direct than that along the Perene. The chief drawback is the interruption of navigation during the period of low water. During high water there is steamer connection from Masisea, the terminus of the Iquitos steamers, on the Ucayali just below the confluence of the Pachitea and Puerto Bermudez. Farther up stream there is canoe connection with Puerto Yessup where the trail from La Merced ends. It is a link in the main route from Lima to Iquitos (compare Mr. Miller's article "The 1927–1928 Peruvian Expedition of the American Geographical Society," elsewhere in this *Review*) and is much traveled.

Mr. Singewald's expedition was primarily geological; the map is used to show the geology, and the accompanying article deals mainly with the stratigraphical succession. An interesting conclusion is hinted at: that the folding of the eastern Andes in this region is even more recent than had been supposed, late Tertiary instead of mid-Tertiary; but definite assertion awaits confirmatory evidence.

**El Tronador and a South American Switzerland.** No one has as yet climbed the summit of El Tronador (11,350 feet), that "superb volcano" on the Chilean-Argentine boundary. Federico Reichert has made three attempts to do so, but in each case an insurmountable obstacle blocked the goal. These attempts are recorded in his article "El Macizo del Tronador" in the new Argentine geographical magazine (*Gaea: Anales Soc. Argentina de Estudios Geogr.*, Vol. 2, 1927, pp. 385–402). Though failing in his avowed purpose, Reichert's efforts have served to renew interest in the Parque Nacional del Sur of Argentina, of which Tronador is the most magnificent feature (El Parque Nacional del Sur, *Gaea*, Vol. 2, 1926, pp. 264–316).

The National Government Line has made Bariloche, on the south shore of Lake Nahuel Huapi, the center of the park, easily accessible from Puerto San Antonio on the Atlantic Ocean. Access from the Pacific is more difficult. The journey from Puerto Montt to Puerto Varas on Lake Llanquihue is made by rail. A boat trip across the lake is followed by an automobile trip to Petrohué on Lake Todos los Santos. After crossing the lake a difficult trip by automobile, on horseback, and by boat leads through the pass of Pérez Rosales on the northern side of Tronador to Puerto Blest at the west end of Lake Nahuel Huapi. The density of the forest growth, the rugged topography, and the long detours necessary to avoid crossing the arms of Lakes Nahuel Huapi and Todos los Santos will prevent the construction of an all-rail route using the pass of Pérez Rosales, which otherwise offers the advantage of freedom from the heavy snows that occasionally block traffic on the Transandine Railway. The establishment of the long-contemplated Chilean National Park adjoining the Parque Nacional del Sur would increase the attractions of the region for tourists and emphasize the need of better transportation.

The panorama viewed from the east side of Tronador suggested to Reichert a simpler route by the Pass of Vuriloche to the south of Tronador. This route he identifies with the famous "lost road" of Vuriloche of the early Spanish days in Chile. If Reichert's view is substantiated it should offer a favorable transandean railway crossing. The distance to the Estero Reloncaví, the eastern arm of the gulf of that name, is short; and the arm is navigable for ocean steamers, furnishing an easy route to Puerto Montt, the terminus of the Longitudinal Railroad of Chile (see Fig. 2, p. 65 of this *Review*).

Argentine railroads extend like fingers towards the Chilean boundary. Chile has contemplated similar development. The railroad extending east from Concepción reaches within forty miles of the Argentine boundary; that leading east from Temuco is less nearly complete. Though a route from Valdivia across the Andes has been surveyed, the expense of construction will probably prevent it from being undertaken. Chile's present unfavorable financial situation, due to the competition between natural and manufactured nitrates, will at best delay the completion of these railroads. The route through the Pass of Vuriloche is, however, in a somewhat different class: it may attract foreign capital interested in the promising tourist trade of this "Switzerland of the Andes."

## EUROPE

**Some Recent Field Studies of Highland Peoples in Europe.** In the *Sociological Review* for October, 1927, Dr. Johann Sölch of the University of Innsbruck deals with the historical and human geography of the Brenner Pass and its immediate vicinity. In the same journal for January, 1928, Professor W. Stanley Lewis and Mr. D. T. Williams present a clear descriptive summary of the observations of a group of British sociological students from Leplay House, London, made in the upper Adour Valley of the French Pyrenees in August, 1926. The competence shown by the authors of this paper in interpreting the geographical environment and its relations to the life of the local population reveals a significant trend in contemporary sociological research.

Patterns of village settlement in the Trentino are analyzed and correlated with the topography and rock structure by Professor Ezio Mosna (La conformazione del suolo e la distribuzione dei centri abitati nel Trentino, *Studi Trentini*, Classe II, Scienze Naturali ed Economiche, Vol. 8, 1927, Nos. 1 and 2). The settlements are grouped according to their location upon such features as valley floors, basins, gentle and steep slopes, mountain spurs, alluvial cones and other detrital slopes, alluvial and rock terraces, *roches moutonnées*, and "saddles."

The common phenomenon of the emigration of highland people is analyzed in

several papers. Auguste Vautier eloquently describes the situation in the Ticino, or Italian-speaking canton of Switzerland (*Bull. Soc. Neuchâteloise de Géogr.*, Vol. 36, 1927, pp. 30–38). Here rugged mountain ridges separate narrow, steep-sided valleys, down which course wild streams. The traveler who strolls through the streets of the densely built villages finds many a deserted dwelling, with its gaping windows and crumbling walls. From some villages people have gone to the United States, from others to the Argentine or to France or even to Holland. Where spring freshets each year wash away more and more of the arable land and cover the lean fields with gravel, boulders, and clay; where avalanches and landslides are an almost constant menace to man and beast, the farmer finds little incentive to remain when more favored regions beckon him. Vautier believes that "the war which Holland wages against the sea should be waged by Ticino against its mountains." Nature, however, is not the only enemy. The land is divided into excessively small holdings, and there are often almost insuperable legal difficulties in the way of consolidating these into larger parcels better adapted to efficient farming methods. In order to acquire a small garden one purchaser "had to treat with twenty-eight proprietors." Nor does the tourist industry offer the resources it used to in the older, more leisurely days when summer visitors would linger among these valleys. Now tourist-laden automobiles rush through the villages without stopping, and railway passengers seldom leave the station platforms.

The Aude, Ariège, and Tet valleys of the eastern Pyrenees were studied by a group of sociologists from Leplay House in August, 1927. Conditions here are interpreted in a suggestive paper edited by Dr. Arthur Geddes in the *Sociological Review* for April, 1928. Population has been rapidly falling off during the last thirty years. In some localities it is less than half of what it was in the middle of the nineteenth century. "At first the decrease seems to have been directly due to emigration; now it is also due to the diminished size of families among those few who stay. The root cause of the present changes is the demand for labor and the offer of a livelihood with short hours and lighter work in industry, commerce, etc., in town, and of better, easier farming in the plains." The school system and conscription are also, in Dr. Geddes' opinion, contributory causes, in that they create among the younger men discontent with the surroundings of their childhood.

Slovakia is divided into a mountainous woodland zone to the north and a rich agricultural belt on the Danubian plains to the south. Although much the poorer in resources, the northern zone has the denser population. The farming land is here scattered in isolated patches and is not sufficient to support the people. This circumstance, together with the long annual respite from agricultural labor enforced by the severity of the winters, has favored the development of a great variety of petty local manufacturing industries, such as wood working, glass making, paper manufacturing, hemp weaving, and pottery work for the men, and hemp spinning, lace making, and embroidery for the women.

The Slovak peddler of small wares, iron wire, glass, cloth, poppy seed oil, wooden objects of various sorts, laces, etc. is a familiar sight throughout the Danubian countries. Before the World War Slovak highlanders also furnished farm labor in the Hungarian plains during the harvest season, which occurs there two months earlier than in the mountains. The new frontier between Czechoslovakia and Hungary, however, by severing the plains from the mountain area, has almost wholly stopped this seasonal migration of farm labor. The Czechoslovak government is attempting to remedy the difficult situation thus created by finding employment for the Slovak laborer in the agricultural lands of Bohemia and Moravia. It is also hoped that the new agrarian law, breaking up the large estates in favor of the peasants, may bring some relief. In spite of these measures, the mountain zone of Slovakia continues to be an area of extensive emigration to the United States, to Canada, and to the mines of northern France. But this emigration, although not seasonal, as

in former days, "is also not an emigration without hope of return. One meets in many of the mountain villages fine, well-cared-for houses built with the dollars of emigrants who have returned home rich, and in nearly every village of the valley of the Vah one finds people speaking the English of America" (Pierre Deffontaines: Petits métiers et petits nomades de Slovaquie, *Rev. de Géogr. Alpine*, Vol. 15, 1927, pp. 567–576).

Mention may here be made of another most unusual type of migration in southeastern Europe, that of the market gardeners of Bulgaria briefly described in the *London Times* (weekly edit., August 16, 1928, p. 178). They come from an area of some 30 miles square about Trnovo, between the Balkan Range and the Danube, where the population is much too dense to be supported on local agriculture alone. For more than a century men of the region have wandered afield, mainly to adjacent countries but in some cases even as far as Belgium and France. In the latter part of last century it is estimated that the number of annual migrants amounted to 12,000. They go in companies of 12 to 15 persons, leaving in early March to return in the autumn. The peasants of this region have thus acquired "an unrivalled knowledge of the geography and economic conditions of Southeastern Europe and know where they can find a market for their produce and suitable land for growing it"; and furthermore they are "more intelligent and have a higher standard of life than anywhere else in Bulgaria."

## AFRICA

**Recent Developments in Ruanda-Urundi.** Much geographical information about the little-known region, Ruanda-Urundi, is to be found in the 1924, 1925, and 1926 reports of the Belgian Government to the League of Nations on the Administration of these territories. The report for 1925 classifies the country on a climatic basis into five natural regions—long narrow belts running in a north-south direction. The first of these is the tropical lowland bordering Lake Tanganyika and the Ruzizi River with rainfall placed at an average of 850 millimeters; the second, directly to the east, consists of the high mountains forming the Congo-Nile watershed with rainfall twice as heavy or more so on the forested heights; the third is the central plateau which, with a temperate climate and rainfall average of 1200 meters, occupies most of the country. Still farther to the east lies the eastern depression, warmer with less rain, a part of the dry belt of eastern Africa. A fifth region may be distinguished in the volcanic district to the northwest where peculiar conditions of soil, fauna, and flora are recognized (the physiography of this district has been described by Hans Meyer in "Morphologie der Virungavulkane in Ruanda, Ostafrika," *Abhandl. Sächs. Akad. der Wiss., Leipzig, Math.-phys. Klasse*, Vol. 40, 1927, pp. 1–31). With the exception of this last district the seasons are well marked and everywhere the rainfall regimen is irregular both as to total precipitation and distribution.

The native population, on the latest estimates from 2,500,000 to 3,000,000 for Urundi and about 2,000,000 for Ruanda, is dominantly agricultural. Like most primitive agriculturists, however, the natives customarily plant only sufficient to last until the next harvest. Indeed, food is generally scarce for a month before the next crop is gathered. The efforts of the administration have been largely directed towards encouraging an agricultural surplus, partly as a basis for export and partly as a famine preventive. Manioc and sweet potatoes, two introduced crops, have not been very popular because they require a longer time to ripen than the bean—the great food staple—pea, and corn crops. They have, however, the great advantage of being more independent of seasonal conditions, as was well illustrated during the famine of 1925–1926 when deficiency of rain caused the failure of two successive harvests. Fortunately government efforts in the plains region had resulted in a surplus of manioc. The more mountainous areas, where the dissemination of

ideas is greatly hindered by the poor means of communication, were badly hit. The apathetic population became demoralized, and strong efforts were necessary to force them to make provisions for the next harvest and to collect them at centers of food distribution. The chiefs, having failed to coöperate with government efforts to get manioc and sweet potatoes planted, a ruling by which, if such crops were not planted, the government in case of famine might appropriate enough of the chief's cattle to feed that chief's people was put into force with good effect. In 1926 there was a decided increase in all crops, including tobacco and coffee.

Ruanda-Urundi lies within the tsetse fly zone, both *Glossina palpalis*, associated with sleeping sickness in man, and *Glossina morsitans*, source of "nagana," cattle sickness, occurring (see I. W. Frantzen: Die geographische Verbreitung und wirtschaftgeographische Bedeutung der Tsetse-Fliege, *Materiaux pour l'Étude des Calamités*, January–March, 1928, Geneva). The infected zone stretches in a north-south belt from Lake Tanganyika east to the elevated lands of the Congo-Nile watershed. The lake plain has the most cases of sleeping sickness, because of the great number of marshes, the swampy banks of the rivers, and the banana groves—all favorite breeding places of the fly. Natives, fishing or traveling from one part of the lake to another, usually put in for the day at numerous inlets whence, after infection, they scatter to all parts of the Territory. The Mandatary Reports for 1925 and 1926 state that a general survey has been made of the whole country, the infected areas defined, and a program drawn up to combat the disease. This plan consists principally of grouping the natives in better locations along the routes of communication, of clearing and draining river and lake shores, of bridging fords, of razing banana groves and substituting other crops, and of regulating the movement of canoes and fishing on the lakes. A comparison between the maps published in the 1924 and 1926 Reports shows considerable diminution of the disease in the southern part. Less change was noted in the northern part, where the infection is not so prevalent.

**Variations in and Possible Disappearance of Lake Chad.** This is the title of a recent paper by Jean Tilho in the *Annales de Géographie* (Vol. 37, 1928, pp. 238–260). Lake Chad in the French Sudan spreads its waters over a nearly level plain. As a consequence, not only is the lake extremely shallow, but fluctuations in the surface level are accompanied by enormous changes in area. Detailed measurements of the levels were made at the post of Bol from October 20, 1912, to September 30, 1919. These showed annual variations in the surface of between .50 and 2 meters; low water occurs in July and high water in December. Besides the seasonal oscillations there are larger fluctuations occurring over periods of several years. During the low-water stages, known as "Little Chad," the lake becomes "an immense swamp with scattered mirrors of open water surrounded by forests of ambash (*Herminera claphroxylon*)." All the northern part becomes "dry, and the inhabitants of the eastern archipelago, now joined to the coast, migrate toward the interior of the lake in search of green pastures and drinkable water, for the water of the many *bahrs* becomes dangerous to man and beast, owing to the concentration of the salts in solution. The coast of Kanem is joined to that of Bornu by the almost complete emergence of a broad threshold, to the north of which remain only vast ponds whose shores are covered by putrefying fish that send out an intolerable stench." During the high-water stage, or "Great Chad," "the lake regains its normal aspect with great expanses of open water."

Historical records throwing light on the dates of the periods of "Great Chad" and "Little Chad" are extremely scanty. Tilho, however, believes that there is sufficient evidence to warrant belief in a correlation between the advances and retreats of the Alpine glaciers and the variations in the lake levels.

Taking into consideration climatological factors alone, Tilho holds that there

need be little fear that Lake Chad will dry up in the near future. A marked depletion of the supplies of water reaching the lake, however, has been brought about through the capture of one of the tributaries of the Logone, which flows into Chad, by the headward erosion of a branch of the Benue. There also seems to be imminent danger that the entire Logone may be deflected into the Benue. This would prove an extremely serious disaster. It would lead to the raising of the annual flood level of the Benue from 1.50 to 2 meters, and also, by depriving Lake Chad of one of its major tributaries, it would hasten the complete disappearance of the lake by evaporation. There seems little question that the lands in the vicinity of Chad are unusually fertile and that their potential value would be gravely impaired by the disappearance of the lake or further diminution of its area. Tilho recommends the construction of a great dam at a critical point in the channel leading from the Logone to the Benue. Such a dam would not only postpone indefinitely the danger of the desiccation of Lake Chad through the capture of the Logone, but would also put a stop to the present annual escape of the flood waters of the Logone into the Benue. "Chad would cease progressively to shrink, assuming again the aspect of a little inland sea with indefinite banks, the aspect which it presented when Denham, Barth, and Nachtigal saw it in the last century."

## POLAR REGIONS

**Some Recent Spitsbergen Studies.** The characteristic of Spitsbergen as a "climatic outpost" is well exhibited in the vegetation map by V. S. Summerhayes and C. S. Elton accompanying their paper "Further Contributions to the Ecology of Spitsbergen" in the August, 1928, number of the *Journal of Ecology*. The meeting of the polar ice pack from the east with the Gulf Stream drift from the west produces a climatic gradient which is reflected in the life of the archipelago. Four vegetational zones are recognized; and, while the animal life is very impoverished as a result of isolation, there is a related distribution among land animals and the intertidal fauna; hence these zones can properly be described as life zones. On a broader scale the zones can be traced across Greenland and Arctic Canada and in the mountains of northern Scandinavia.

The vegetation of Northeast Land falls almost entirely in the Barren Zone. The ice-free ground is covered with rocky débris. "In some places, as at Murchison Bay, it is possible to walk for miles over the frost-shattered surface without seeing more than an occasional tuft of poppies." In the most favorable spots is an open growth of Arctic willow. Conditions are better in West Spitsbergen. In the exterior coastal regions, subject to sea fog, the mountain avens (*Dryas octopetala*) is a dominant form. Passing up the fiords, where the fog does not penetrate and where the temperature gradient is further heightened by the prevalence of föhn winds off the glaciers, the vegetation is richer. Heaths of the white arctic bell heather (*Cassiope tetragona*) occur characteristically. With further penetration we reach the fourth zone of most varied vegetation with species not found elsewhere in the islands. Thus, while Spitsbergen is beyond the tree, or even the scrub, limit, the dwarf birch is found in Coles Bay, Ice Fiord.

This paper by Messrs. Summerhayes and Elton is based mainly on work of the Oxford University Expeditions to Spitsbergen in 1921, 1923, and 1924. The general purpose of these expeditions has been told by Mr. George Binney, organizer and secretary of the first and organizer and leader of the second and third expeditions, in "With Seaplane and Sledge in the Arctic" (London, n. d.). The volume is primarily a narrative account of the third expedition, whose labors were devoted for the most part to Northeast Land. The preface by W. J. Sollas gives an excellent brief résumé of the work accomplished. Eventually the scientific results of the 1923 and 1924 expeditions are to be published in collected form as was done with the first

expedition, "Spitsbergen Papers," Volume 1 (1925). Meanwhile reference may be made to some of the other papers that have already appeared.

"The Geology of North-East Land (Spitsbergen)" by K. S. Sanford (*Quart. Journ. Geol. Soc. of London*, Vol. 82, 1926, pp. 615–655) is specially interesting in that the author traces here the outer margin of the great arc of Caledonian folding that runs from Great Britain through Norway and Spitsbergen and northern Greenland. He also outlines the tectonic movements of late Tertiary time in which Northeast Land was cut off from the main island and cleft from west to east by the great fiord of Wahlenberg Bay.

Minor forms of the landscape are dealt with by Mr. Elton in "The Nature and Origin of Soil-Polygons in Spitsbergen" (*ibid.*, Vol. 83, 1927, pp. 163–194). To the problem of this common phenomenon of Arctic and Alpine regions Mr. Elton makes helpful contribution by viewing it in three dimensions instead of the customary two (compare "Notes on Surface Markings in Spitsbergen," *Geogr. Rev.*, Vol. 14, 1924, pp. 486–487). He finds that an essential part is played by differential frost action in a vertical plane. The lower layers of the soil are wetter than those above; hence frost splitting is more intense on that level with production of more finely comminuted material. Frost action humps up mud from these lower layers, and the overlying stones are pushed aside. Disintegration of the stones continues, and the final stage may be a "mud-polygon." Mud polygons are well developed where frost action is particularly intense or rapid, as above Hinlopen Strait, where fogs around the pack ice are thick and temperatures low, or on Reindeer Peninsula, where the rock is a soft shaly sandstone. The polygons have a marked effect on the distribution of plant and animal life: while their slightly convex domes are bare, the borders are likely to support a thick mat of vegetation.

FIG. 1.—Vegetation zones of the Spitsbergen archipelago, redrawn from the map by Summerhayes and Elton. The numbers have reference: 1, Barren zone; 2, Dryas zone; 3, Cassiope zone; 4, Inner Fiord zone. The areas left blank are mostly covered with permanent snow and ice. The broken line indicates the approximate limit of the ice pack in summer; the arrows show the direction of the ocean currents.

Northeast Land with an area of some 8000 square miles is largely covered by an ice dome rising to about 2300 feet and reaching the sea along a large part of the coast. Observations on the influence of this mass on the climate have been made by Mr. Sandford in "Summer in North-East Land, 1924: The Climate and Surface Changes" (*Geogr. Journ.*, Vol. 68, 1926, pp. 200–225). He concludes that: "There appears to be a type of 'intermittent glacial anticyclone,' which establishes itself, is blotted out by interference from outside the area, and quickly reëstablishes itself again.

Winds are most markedly outward-flowing, and lead to a definite augmentation of the bordering ice at the expense of the higher parts of the interior. There is some indication of a pulsation, from calm to blizzard. In summer the effect of this type of 'anticyclone' is very marked, and it is a factor of real importance in the control of the supply of the cap of ice."

In 1927 the Cambridge Expedition under the leadership of Mr. H. G. Watkins carried out investigations in Edge Island which, like the rest of eastern Spitsbergen, is less known than the west because of relative inaccessibility (H. G. Watkins: The Cambridge Expedition to Edge Island, *Geogr. Journ.*, Vol. 72, 1928, pp. 117–143). The only accurate mapping on the island was that of the Russo-Swedish Arc of Meridian Expedition of 1899–1901. While weather prevented the Cambridge Expedition from carrying out its complete program, some surveying was done on the southern coast and in the northwestern corner of the island. About one-third of the island is ice-covered in the form of domes rising to about 1500 feet arranged in a horseshoe shape around the center of the island, the ice reaching the sea on the south and east coasts. The ice cover seems to be diminishing; only at the highest point, above 2000 feet in the center of the island, does accumulation appear to be going on. Where the glaciers do not reach the sea they are in a state of retreat.

About fifty miles south-southeast of Edge Island is Hope Island, whose position and size have been shown more correctly on some of the ancient maps than on those of recent date. The island has now been mapped (1924) by Captain Thor Iversen in the course of his fisheries investigations in Spitsbergen waters on behalf of the Norwegian Government. The island, consisting of seven flat-topped hills sloping sharply to the shore, is 20 miles long and one-half to one mile wide. It is evidently a remnant of a larger land mass and is fast being reduced to a shoal by the attack of frost and surf—a process, however, that has been slowed down by recent elevation. Vegetation occurs in scattered places only, and the number of species is very small. The island has occasionally been used as a hunting station.

Captain Iversen's paper, which is entitled "Hopen (Hope Island)" forms Number 10 (1926) of Volume 1 of *Resultater av de Norske Statsunderstøttede Spitsbergenekspeditioner* (Oslo). This valuable series which publishes the results of the Norwegian state-supported Spitsbergen expeditions is being continued under the title of *Skrifter om Svalbard og Ishavet* (see below). Number 16 of the series "Déterminations Astronomiques" by Hans S. Jelstrup describes the determination of the astronomical position of Ankershamn, the wireless station at Green Harbor.

**Scientific Exploration in Svalbard.** The Norwegian Government has issued the following memorandum relating to the Organization of Survey Work and Scientific Exploration in Svalbard.

The Norwegian Government has established a central institution under the Ministry of Trade for the exploration of Svalbard and polar regions. This institution, the name of which is Norges Svalbard- og Ishavs-undersøkelser (Norwegian Scientific Exploration of Svalbard and the Arctic Sea), 34 Bygdø allé, Oslo, embraces, *inter alia*, all official survey and geological work and other natural-historical and geophysical exploration in Svalbard and also the survey of adjacent waters. This does not, however, include meteorological observations, which remain under the Meteorological Institute in Oslo, or special fisheries research, which is attached to the Fisheries Board at Bergen.

In order to achieve the best possible results in the scientific exploration of Svalbard it is essential that all expeditions intending to carry on such work in those islands give notification thereof to the Norwegian Ministry of Foreign Affairs and, in addition, send in particulars respecting the expedition to Norges Svalbard- og Ishavsundersøkelser. These particulars should comprise a statement of plans—the scientific work to be undertaken, the territory to be covered, equipment, vessel, provisions,

and personnel. The Norges Svalbard- og Ishavs-undersøkelser will then consider such plans. It will ascertain whether the work contemplated has already been done in whole or in part and whether there may be other expeditions already operating in the same tracts or contemplating so doing. This institution will, on request, supply information about literature and maps bearing upon the work contemplated, about scientific material in course of preparation, and the making of maps that may be of value to the expedition; it will also give practical hints relating to natural conditions and equipment. In addition, this institution will be able to give advice as to the particular Norwegian port at which the expedition should call for equipment control (see below) and furnish any other information required about sailings to Svalbard and of the possibility of procuring housing accommodation for the members of the expedition at the settlements in the islands. It is also the duty of the Norges Svalbard- og Ishavs-undersøkelser to give expeditions the necessary information relating to such Norwegian laws and regulations, e. g. close time provisions, as may be involved.

The services thus rendered by this institution are to be entirely free of charge, providing expeditions do not require reports involving a considerable amount of work or extra outlay. If, however, the institution is to fill its position efficiently as an inquiry office for Svalbard, the expeditions, on their part, must immediately on their return home submit a preliminary report on the work done and the results achieved. Further, they must send in two copies of all papers, books, and maps that may be published as a result of their work.

With a view to ending the chaos that has long prevailed in regard to geographical names in Svalbard, the Norwegian Government has initiated a comprehensive plan for the final determination of names for each locality. This work will be completed in about a year. To avoid further confusion in this direction each expedition desiring to give new geographical names must submit its proposals to the Norges Svalbard- og Ishavs-undersøkelser (foreign expeditions must send their proposals through the Norwegian Ministry of Foreign Affairs). This institution will consider such proposals and submit a recommendation. The final decision lies with the competent Norwegian authority.

Furthermore, attention is called to the fact that by Act of August 6, 1915 (see also Orders in Council of Dec. 15, 1917, Sept. 3, 1920, and Jan. 17, 1928) the equipment and provisioning of Norwegian expeditions to Arctic regions is subject to official control. This act primarily concerns hunting expeditions but applies also to expeditions fitted out at Norwegian ports for purposes other than hunting when they state, or there is cause to believe, that they intend to spend part or the whole of the winter in those regions. It moreover embraces expeditions made under such conditions as may necessitate wintering even though this may not be intended. Then again, the provisions of this act are applicable to foreign expeditions engaging as members Norwegian subjects in Norwegian ports, when it is stated, or there is cause to believe, that such expeditions have the intention of wintering or are proceeding to such tracts or such conditions as may necessitate wintering.

Notification of expeditions must be made to the *Politimester* (Superintendent of Police) at the port where they are fitted out; but in respect of foreign expeditions such notification may be given through Norges Svalbard- og Ishavs-undersøkelser, in which event the Norwegian port from which the expedition intends to sail must be stated. Control is exercised by a committee comprising a government ship surveyor and a second member with experience of wintering conditions in Arctic regions; the latter shall be nominated by the president of the court.

It has been found necessary to exercise such a control as this act establishes, for it happens not infrequently that expeditions and persons proceeding to Svalbard are so poorly equipped that they get into difficulties. If such an expedition is in distress some of its members may reach one of the settlements where there is a tele-

graph office and report that the remaining members are in peril and require immediate help. Should some time elapse without any news coming in about an expedition, demands for a search will very soon be heard. In such instances the Norwegian Government has had to send out or cause to be sent out relief expeditions. Also out of consideration for the coal-mining companies in Svalbard the control of touring, hunting, and scientific expeditions is a necessity. It has happened that expeditions have arrived at Svalbard so poorly fitted out that they have become a burden to the neighboring mining community from the first, and it is not always an easy matter for the mining companies to afford adequate help. In the summer months it does not matter so much, but it is a serious problem for these companies when members of some expedition or other that is in a helpless plight suddenly appear in midwinter and have to be furnished with shelter, food, and medical aid, or may perhaps require a relief attempt.

As has already been mentioned, meteorological work in Svalbard is in the charge of the Norwegian Meteorological Institute. The Norwegian Government has established two meteorological stations in Svalbard, one being at Tunheim on Bear Island and the other at Ankershamn, Green Harbor. The Norwegian Meteorological Institute will, on request, give scientific expeditions wishing to work in Svalbard all necessary information respecting climatic conditions and the meteorological work done there.

It may also be pointed out that Norges Svalbard- og Ishavs-undersøkelser publishes *Skrifter om Svalbard og Ishavet* giving an account of all scientific results published in Norway from those regions. Foreigners will also be given the opportunity of having their papers printed in this publication series, on condition that they defray the cost of printing.

## PHYSICAL GEOGRAPHY

**Physical Characteristics of Sea Ice and River Ice.** Dr. Finn Malmgren's work "On the Properties of Sea-Ice," published as Volume I, Number 5, of the Scientific Results of the Norwegian North Polar Expedition with the "Maud" 1918–1925 (Bergen, 1927), contributes basic data in a still imperfectly known field. While a purely physical exposition, the work has its geographical bearings, for sea ice plays an important if not fully comprehended rôle in the general circulation of the globe, as the veteran investigator, Dr. Otto Pettersson, shows in his paper elsewhere in this number of the *Geographical Review*.

The way in which salt exists in ice is of fundamental importance. In water salt is present in homogeneous solution, in ice it is found as a concentrated brine in cavities of the pure ice and at low temperatures as small crystals all through the ice. The condition is unstable; during the summer time when melting takes place, the brine moves downwards; the phenomenon of fresh-water pools on the surface of old ice is well known. The state in which the salt is held in the ice leads to abnormalities in its physical properties. The peculiarities of the latent heat of fusion and the heat expansion of sea ice, first investigated by Otto Pettersson, were followed up by Dr. Malmgren, and new work was done on other physical constants: the first determination of the specific heat of sea ice was made, and the first precise observations on the specific gravity of sea ice in the interior of the Arctic Sea were taken.

Records were obtained of the temperatures of sea ice, and comparison was made with Nansen's findings on the *Fram*. The temperature data were used for calculation of the thermal conductivity of sea ice with very important conclusions. During the period September to April, heat is conveyed to the atmosphere above the Arctic Sea in such quantity as to raise the lower layer—some 150 meters thick—an average of 6.9° C. This amount of heat "greatly contributes to diminish the cold of winter and explains the fact that, despite the clear winter sky and the calm weather, we

have over the Polar Sea considerably milder winter temperatures than further south over the continent of Asia."

Parenthetically reference may here be made to the appreciations of Dr. Malmgren's life and works by Axel Wallén and H. U. Sverdrup in *Ymer*, Vol. 48, 1928, pp. 243–245 and 246–252 respectively.

From theoretical considerations we turn to a question of immediate practical interest in Howard T. Barnes's new work, "Ice Engineering" (Montreal, 1928), dealing mainly with river ice. Since his earlier work, "Ice Formation" (1906) was published, Dr. Barnes has continued the study of the physical behavior of fresh water ice in relation to methods of ice control with good results. Features upon which he lays particular stress are the significance of small temperature differences in ice formation and the importance of ice prevention. In the chapter on "Ice Navigation and Ice Breaking" he gives many instances of the success attained. Thus, since 1908 ice breakers have succeeded in clearing out the great ice jam that forms at Cap Rouge just above Quebec and have thus kept the river open to Three Rivers and have prevented the former winter flooding of riverine farms between Lake St. Peter and Quebec. The chapter on "Ice Remedial Work" discusses such methods of control as flood lighting, which simulates the disintegrating action of sunlight, and his own experiments with thermit for destroying ice jams and icebergs (compare the note "Recent Work on Iceberg Drift and Control in the North Atlantic," *Geogr. Rev.*, Vol. 17, 1927, pp. 678–679). As Dr. Barnes aptly observes, "In northern countries an ice engineer is as essential as a highway engineer."

**The Influence of Forests on Rainfall and Run-off.** While the definite solution of the problem of the influence of forests on rainfall and floods is still to be solved the matter is of perennial interest. Raphael Zon's paper "Forests and Water in the Light of Scientific Investigation" originally published as an appendix to the "Final Report of the National Waterways Commission, 1912" was reprinted by the Forest Service in 1927. The text is unchanged; but the bibliography, a very valuable feature, has been brought up to date. "Forests and Floods," by Ward Shepard (*U. S. Dept. of Agric. Circular No. 19*, 1928), inspired largely by the Mississippi floods, presents many striking examples of devastation wrought on denuded woodlands, overgrazed hillsides, and eroded farms but brings no new light to bear on the problem. A new approach, however, is offered by Dr. C. E. P. Brooks in a useful contribution made under the above title to the January, 1928, number of the *Quarterly Journal of the Meteorological Society*. Dr. Brooks has made a critical analysis of various statistical investigations into the problem and has arrived at certain conclusions therefrom. His conclusions are:

1. The replacement of forests by field crops or grassland probably tends to increase the general rainfall of the district slightly; their replacement by bare ground probably tends to decrease the general rainfall slightly.

2. Forests increase the local rainfall by one to two per cent, this effect being due to the increase in the effective level of the ground by the height of the trees and by the greater friction of the wind with the tree surface compared with open ground.

3. To this may be added, in favorable mountain situations, an increased supply of water collected mechanically from clouds which envelop the forests.

4. Afforestation of grass or crop land probably increases the local run-off by ten to twenty per cent, this amount being made up partly by the decreased loss of water in evaporation and transpiration, partly in the slight increase of actual rainfall. This is likely to be the most noticeable effect of afforestation. Afforestation of bare ground would decrease the run-off, but this effect would be masked by the much greater regularity of the flow.

5. Forests, drawing their water supply from deep sources, possibly exercise a slight mitigating effect on droughts.

## GEOGRAPHICAL NEWS

**The Angrand Prize Award to Koch-Grünberg.** The international Angrand prize for studies in the Americanist field, the distribution of which is in the hands of the Bibliothèque Nationale, Paris, has for the present year been awarded to Theodor Koch-Grünberg, in memoriam. In making this award, French science has paid a tribute to a German who was of outstanding merit both as a scientist and as a man.

Koch-Grünberg was one of the many students who are to be numbered among the followers of Karl von den Steinen; perhaps he has achieved more than any other of them. He began his long series of South American field studies by taking part in Dr. Hermann Meyer's Xingu expedition in 1898–1900. During 1903–1905 he made his first independent journey of exploration, on which he carried out a thoroughgoing study of the Indian tribes occupying the banks of many of the tributaries of Rio Negro. The principal work resulting from that journey was "Zwei Jahre unter den Indianern" (Berlin, 1909–10), in which he presents a detailed study of the habits and customs of the Indians and especially their mask dances. It is an excellent travel narrative that should be made available in an English translation. In many treatises, large and small, he worked up the extensive linguistic material collected. In the years 1911–1913 Koch-Grünberg again undertook an important journey, during which he studied the Indian tribes located between Roraima and the Orinoco. The results of that expedition are embodied for the most part in his great work, "Von Roraima zum Orinoco," published in several parts, one of which has appeared since his death. It is for the last-mentioned part of that work that the prize has formally been awarded. It deals exhaustively with the culture and language of the Indians. In one part he gives a masterly account of the actual journey; and this, too, should be translated into English. The World War and the following economic depression prevented Koch-Grünberg, as it did many others, from continuing his journeys of exploration, a state of things that to him, with his love for active work, was very trying. During that period (1913 to 1924) he was Director of the Stuttgart Ethnographical Museum, admirably organized by him and now ranking among the best in Europe as regards its American collections.

In 1924 Koch-Grünberg received an offer to participate in the Orinoco expedition then planned by Dr. Hamilton Rice. However, as it turned out, he took part only in the first stages of that expedition. In October, 1924, he died on Rio Branco from malaria, and by his death American research suffered an irreparable loss.

Koch-Grünberg was no theorist. As far as I can find he never indulged in speculations about the age of man in America, about Graebner's "Kultuskreislehre," and such like. His outstanding achievement lies in his collection of a vast body of observations on the mental and material culture of the Indians and his publication of this material in an excellent manner. He possessed in high degree the power of acquiring the friendship and confidence of the Indians, who rewarded him by allowing him to obtain a deep insight into their inner life. To Koch-Grünberg the Indians were no mere objects of study; they were, above all, fellow beings, unfortunately and hopelessly involved in a struggle against so-called civilization.

In conclusion it should here be pointed out that, although first and foremost an ethnographer, Koch-Grünberg did not neglect geography; and there is no doubt that he has contributed very materially to the improvement of the maps of northwestern Brazil.

ERLAND NORDENSKIÖLD

### OBITUARY

**Thomas Chrowder Chamberlin.** Professor T. C. Chamberlin, long recognized as the dean of American geology and a commanding figure in science, died in Chicago, November 15, 1928, at the age of 85. Notice of his passing came shortly after announcement of his last book "The Two Solar Families," a revision of the well known

work "The Origin of the Earth." Evidently the remarkable vigor and clear mentality that always characterized him remained to the end. It seems fitting that the last year of his life marked the rounding out of those studies in cosmogony and geology for which he is especially famous.

Only a year ago Professor Chamberlin appeared before the Geological Society of America at its annual meeting in Cleveland. For the second time within four years he was the recipient of a medal for outstanding contributions in geology. All who heard his address on that occasion were impressed with the remarkable preservation of his faculties. His enthusiasm and the breadth of his scientific outlook seemed unimpaired, and obviously the kindliness of his nature had not suffered with years. Before all else this aspect of the man deserves emphasis. His many students recall with gratitude and inspiration the simplicity and wholesomeness of his personality.

Chamberlin was born and reared in the Middle West, and most of his work was done in his native section. Few geologists have been more versatile. As head of the Geological Survey of Wisconsin he was confronted with problems of diverse character; and it was his habit not merely to do the task at hand, but to do it exceptionally well. Glacial geology engaged his early attention, and he was the first in America to find conclusive evidence of successive glacial stages in the Pleistocene. The mechanics of glacier motion and the cause of glacial climates are among the subjects to which he made valuable contributions. He also turned his attention to problems of sedimentary rocks and to the metalliferous deposits of Wisconsin. The merit of his discussion on lead and zinc is still recognized by economic geologists.

For more than twenty years Chamberlin was in charge of the glacial division of the U. S. Geological Survey, and during that time he contributed many important papers on subjects related to glacial geology. Other large tasks claimed much of his energy during the same period. For five years he was president of the University of Wisconsin. In 1892 he accepted the headship of the new department of geology in the University of Chicago, a position which he held until his retirement in 1919. *The Journal of Geology*, of which he was editor for 35 years, was founded in 1893. In collaboration with his colleague, R. D. Salisbury, he prepared the well known Chicago textbooks of geology.

Chamberlin's bibliography, arranged chronologically, reveals a fundamental change in his interest beginning in the year 1900. Up to that time he wrote chiefly on glacial geology and climatic changes; in 1900 the emphasis shifted to questions of earth origin. Obviously, he was led into the field of cosmogony largely through his study of the atmosphere. Several papers marked the evolution of his new ideas, and the three-volume "Geology," which appeared in 1904, gave large space to his planetesimal hypothesis. The breadth of his interest in geology always remained, but his later writings were devoted largely to development of the hypothesis and discussion of its geologic consequences. A series of articles on "Diastrophism and the Formative Processes" extended through a period of several years, and another series on "Fundamental Problems of Geology" ranges from 1904 to 1928 in the Yearbook of the Carnegie Institution. "The Origin of the Earth," which appeared in 1916, brought together the developments of the Chamberlin-Moulton hypothesis up to that time, and "The Two Solar Families" gives the final results of the long study.

Chamberlin's contributions to geologic thought have been extensive and profound. His greatest effort was in a speculative field, and appraisal of its ultimate value must await future developments. It is significant, however, that all prominent modern hypotheses on the evolution of the solar system have adopted Chamberlin's idea of biparental origin. This fundamental conception is his, and it has marked a new point of departure in studies of cosmogony.

CHESTER R. LONGWELL

# GEOGRAPHICAL REVIEWS

## South America in the "Géographie Universelle"

Pierre Denis. **Amérique du Sud.** Part I, 210 pp.; maps, diagr., ills., bibliogr.; Part II, pp. 211–479; maps, diagr., ills., bibliogr., index. (Géographie Universelle, Vol. 15). Librairie Armand Colin, Paris, 1927. 50 frs. for Part I, 70 frs. for Part II. 11½ x 8 inches.

A generation has passed since Elisée Reclus brought to a close the publication of his monumental "Géographie Universelle." The two volumes on South America concluded the series in 1894. When they were written, the era of the first scientific exploration of the continent by a series of remarkable naturalist travelers was complete. But since then other workers, more modern in their scientific equipment than were the original explorers, have been in the field, and the time has now come for a new "Universelle." It is a matter for satisfaction that the editors of the new work were able to secure M. Pierre Denis as the author of "Amérique du Sud." Since the nineties, geographical description has acquired a well recognized technique; and a wide public, both technical and general, had good reason to know from his excellent books on Brazil and on Argentina that Denis is a talented geographer and an excellent exponent of modern geographical writing who furthermore has the ability to say much in few words.

The first fifth of the work comprises four general chapters on South America, viz.: structure and relief; climate, including relation to vegetation; native population; colonization. Throughout the remainder of the work each chapter deals either with a natural region within limits based upon physical factors and upon the trend of colonization or with a political unit subdivided into its own natural regions.

While the main function of the author has been to present a regional geography of South America it must be recorded that in the process he has produced a valuable synopsis of the several physical aspects of the continent.

The aggregate amount of geological information that has been brought together in the book is large, and in general it is properly utilized in the text as a geographical element, being mainly directed to surface forms.

The land form descriptions are excellent and concise both in the opening chapter and throughout. While the evidences of erosion cycles are introduced into most of these, the author does not lose sight of the different significance of such traces in different climates. For example, in regard to Brazil where on the great central plateau the forms are clearly attributable to two or more cycles of normal erosion, in the southeastern coastal zone and again in the Guianas the processes peculiar to hot humid climates are invoked to account for the surface. There, owing to the profound chemical decomposition, running water hardly reaches the solid rock; and in such conditions the forms characteristic of stages in the normal cycle do not prevail. The morphological passages indeed contain many masterpieces of compilation and of compression; for example, that dealing with northeastern Brazil and its superimposed drainage system; that of Goyaz, a description pieced together from the work of several explorers; that of the Amazonian surface, represented as the result of depression succeeding elevation and dissection, so that the alluvial margin is likened to a ria coast; or of the Amazonian rivers, where the essential contrast between "white" and "black" rivers (*rios brancos* and *negros*) is explained. The Andean chapters also furnish many excellent examples. In writing of Ecuador, it may be noted, the author challenges Meyer's glacial origin of the high basin fillings, and

argues in favor of excessive water deposit during the major volcanic period. In describing the llanos of Venezuela, again, he points out the danger of drawing conclusions as to the nature and origin of their deposits on the basis of the very local observations so far made.

The origin, amount, and incidence of rainfall are summarized in two interesting maps, on one of which notes are printed showing the months in which the main harvests, movements of stock, etc., take place. The reader, after having the salient features of each climatic type presented to him in a general way in this chapter, will have these essentials indelibly impressed upon his mind as he proceeds. It is not merely that many phenomena that have long been puzzling may well be explained to him for the first time; as, for instance, the *friaghem* of the central regions—abnormally cold and foggy spells with southerly winds in winter—or the distribution and uncertainty of rain in northeastern Brazil. It is rather because the author never omits to connect the vegetation with the climate and above all because the effect of the regimen upon man is constantly reiterated that this account of climate is well nigh unique. But of both these matters, more anon.

The colored map showing the nineteen major vegetation associations of the continent is new, clear, and valuable. The plant life is further given its proper place in every landscape described; its distribution is illustrated in many of the maps, and the author is at pains to explain it not only by reference to climate but to soil. Special attention is devoted to this in inner Brazil, where in a general way the northern limit of the sandstones of the Matto Grosso plateau coincides with the southern boundary of the continuous Amazonian forest with *javary* palm and the *castanheira*; and again about the head streams of the Paraguay there is surprisingly little forest, but tree growth is found to be specially favored on the basaltic ridge that extends parallel with and south of the scarp of the sandstone plateau. In the interesting marginal region of southern Brazil, while the main points are well selected to show the transition between tropical and temperate climates—the limits of orange, coffee, and sugar cane being noted—the effect of soil as determining the forest margins is also stressed. The Andean chapters contain very considerable data regarding the altitudinal and latitudinal ranges of associations and forms of agriculture.

Denis never fails to consider the time element. The seasonal rhythm appropriate to each region is outlined, and the annual pulsation of human life with its many variations is admirably emphasized. A serious student of this book should have no difficulty in discovering what is the particular employment of the average inhabitant of all the regions of the continent at any given month of the year. And he will have been taught to understand the reasons.

It is difficult to select passages regarding the human geography for special notice. But to take two very different regions, Colombia and northeastern Brazil. The Colombia chapter requires close reading, for this is a complex region. From its position and remarkable relief there results a great variation in climate. But so well is all this handled that the reader will reach a full understanding, for example, of a curious phenomenon, the complete reversal of the agricultural year within two degrees of latitude. This may be set down as follows:

| *Bogotá plateau* | *Antioquia* |
|---|---|
| February: main sowing | September: main sowing |
| August: main harvest | January: main harvest |
| September: secondary sowing | March–April: secondary sowing |
| December: secondary harvest | August: secondary harvest |

The evidence of the virility and energy of a section of the Colombian people will surprise many readers. The state of Antioquia, without immigration, more than quadrupled its population in the period 1808–1884. Moreover, the account of the vigorous campaign of forest clearance and colonization by which this population

penetrated southward on the Central Cordillera during the mid-nineteenth century recalls the cutting of the way to the Pacific in the northern continent.

In the description of the Sertão of northeastern Brazil, where the cattle herding requires much exacting labor owing to the drought, cultivation is shown to be normally restricted to land of two types: the *rocados*, clearings in the bush enclosed against the cattle and sown at the onset of the rains, and the *vasantes*, consisting of low-lying damp ground. The way in which a departure from climatic means affects this district—as it does frequently—is explained. Thus, quite short periods of intense drought occurring during the *invierno* ruin the crops on the *rocados*, while excess of late season rains swamp the *vasantes*. The periodic exodus of population from this region after excessive drought has often been noted and also the splendid efforts for drought resistance by water storage and by building roads and railways which incidentally foster the cotton-growing industry of the Sertão.

The illustrations of these volumes of the "Universelle," both photographs, diagrams, and maps, are admirable. Only those who have made the search will know that the topographic maps that are given represent the cream of South American surveys, and will be aware of the general lack of such maps for most of the continent. But the point to stress here is that M. Denis has inserted these. The maps of all kinds and scales are clear, well drawn, and most helpful; many of them are, in part, original. But the fact remains that much of the work cannot be properly followed without constant reference to other maps. And unfortunately no atlas is really good enough. The sheets of the American Geographical Society's Millionth Map of Hispanic America, as far as these have been published to date, supply this need.

ALAN G. OGILVIE

### THE IRRIGATION PROBLEM IN THE UNITED STATES

R. P. TEELE. **The Economics of Land Reclamation in the United States.** xv and 337 pp.; maps, diagrs., index. A. W. Shaw Co., Chicago and New York; A. W. Shaw & Co., Ltd., London, 1927. $4.00. 8½ x 6 inches.

This book on reclamation by the late Dr. Teele was written from a long experience in Federal Departments, and, as might be expected, it is a comprehensive and inclusive survey of the field. Specific attention will here be called to a few chapters of more particularly geographical interest, namely, Chapter II on the Place of Irrigation and Drainage in our National Economy, Chapter VII on the Rate of Utilization of Reclaimed Land, Chapter X on the Relations between Physical and Economic Conditions, and Chapter XI on Future Irrigation and Drainage Policies.

The tables and the accompanying text in Chapter II are source materials covering many phases of irrigation. Here in compact form are collected data of the extent of irrigated and drained lands, of the possible extent of irrigation, importance of crops under irrigation, and future needs for such enterprises. Crops grown under irrigation have to bear the expense of water rates and also, since a large market is generally distant from the arid lands, the long freightage. Competition therefore becomes a factor with the farmer of irrigated lands particularly if he seeks the same markets as the humid-area farmer. The question of subsidization arises and has to be worked out on the process of equalization so that injustice will not result to either the arid-land farmer or the humid-land farmer.

In Chapter VII the rates of utilization on a number of projects are graphically portrayed in order to show the lag between expenditures for irrigation and the use of the land. This lag is considered by many as the main reason for the seeming failure of irrigation from the financial standpoint. Only a few of the projects have the entire irrigable areas under cultivation; while the great bulk of them are not yielding an adequate return for the money expended.